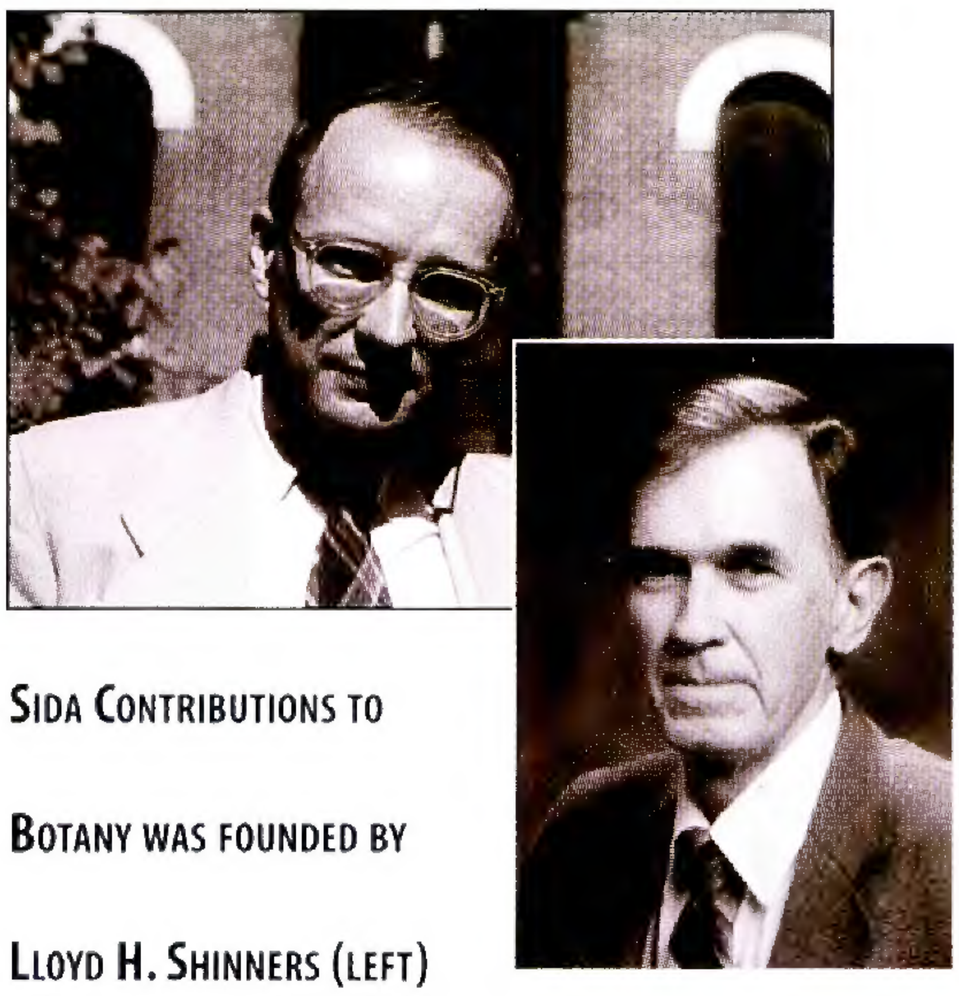
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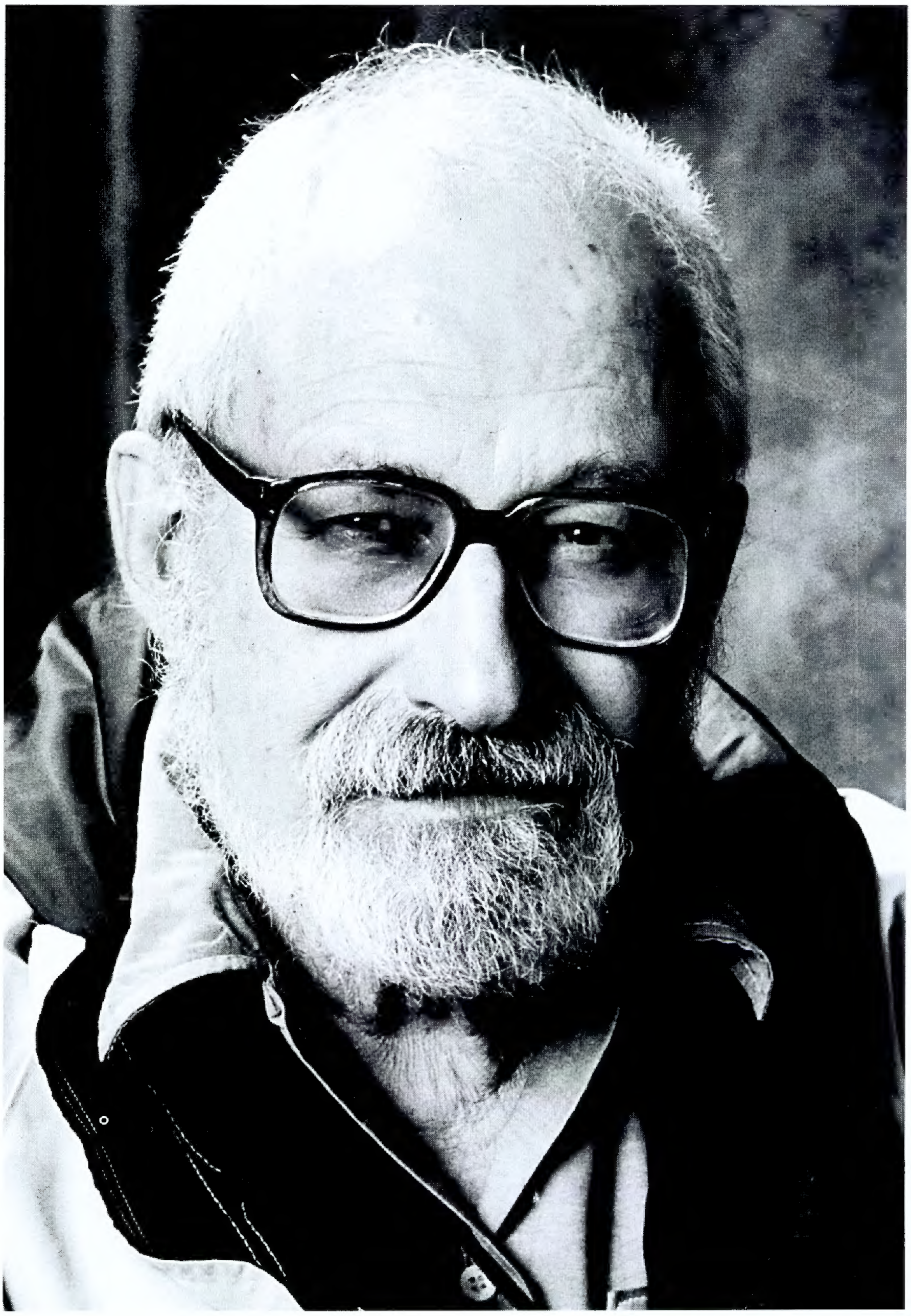
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JOHN W. THIERET, ASSOCIATE EDITOR
FROM 1972-2005

This issue of* Sida *is dedicated to you
and your enormous contributions to the journal!

For all that you've done I thank you!
Barney Lipscomb, Editor

To everything there is a season
and a time to every purpose under heaven:
a time to be born and a time to die;
a time to plant and a time to pluck up that
which is planted ...

Preceding page: John Thieret at his book signing of National Audubon Society Field Guide to North American Wildflowers: Eastern Division in 2001.

JOHN W. THIERET (1926–2005)

Ralph L. Thompson

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ABSTRACT

John W. Thieret (1926–2005), an internationally recognized American plant taxonomist, is remembered as a consummate field botanist, exemplary teacher, acclaimed author, superb editor, fine herbarium director, inspiring mentor to students and colleagues, and noble friend.

RESUMEN

John W. Thieret (1926–2005), taxónomo de plantas estadounidense reconocido en todo el mundo, es recordado como un consumado botánico de campo, un profesor ejemplar, un autor aclamado, un magnífico redactor, un excelente director de herbario, una inspiración como mentor para sus estudiantes y colegas, y un noble amigo.

One of the most renowned American plant taxonomists of the 20th century has died. It is with great sadness and a profound sense of loss that this reflective tribute is written about the life and career of John W. Thieret, Professor Emeritus of Biological Sciences at Northern Kentucky University, retired Director of the Northern Kentucky University Herbarium, and Associate Editor of *Sida, Contributions to Botany*, and Editor of the *Journal of the Kentucky Academy of Science* (JKAS). John suffered a brain aneurysm at his home in Alexandria, Kentucky, on 6 December 2005, while editing a manuscript for the JKAS. He never regained consciousness and died on 7 December. He was 79 years old.

John William Thieret was born on 1 August 1926, in Chicago, Illinois, the only child of Hans and Lorena Thieret. Growing up, he was interested in plants and became an avid student of botany during his school days at Hyde Park High School. At Hyde Park, John met his future wife, Mildred Wolf, fittingly in a botany class. After working briefly in Chicago, John moved to Logan, Utah, to study at Utah State University. Three years later, Mildred also moved to Logan and attended Utah State. They were married on 13 March 1950, by one of their professors, after completing their Evolution final exams. Both earned their B.S. degrees in 1950: John's in Botany and Mildred's in Bacteriology. They remained at Utah State University for graduate work and in 1951, John earned his M.S. in Botany with a thesis in barley genetics and Mildred completed her M.S. in Bacteriology. They then returned to Chicago, where John attended the University of Chicago to work on his doctorate under Theodor K. Just, Chief Curator of the Chicago Field Museum of Natural History. John received his Ph.D. in Botany in



John's senior high school photo at Hyde Park High School, Chicago, ca. 1946.

1953. The title of John's dissertation was "*Gross Morphology of the Seeds of the Scrophulariaceae and Classification of the Family.*"

Later in 1953, John became Assistant Curator of Economic Botany at the Chicago Field Museum and then Curator of Economic Botany from 1954 to 1961. While at the Field Museum, he made collecting trips to Cuba, Mexico, the north-

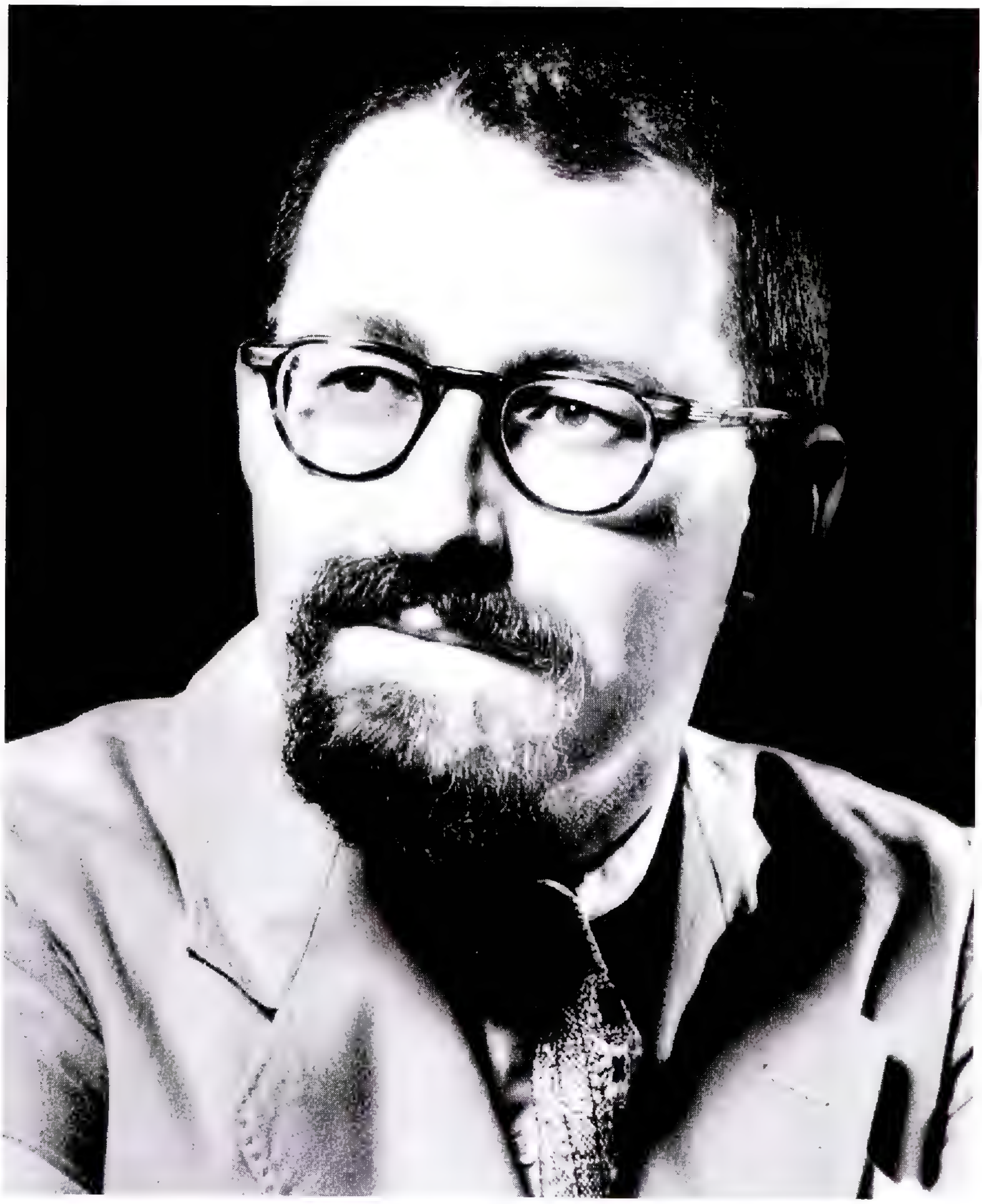
ern Great Plains of the United States, and the Northwest Territories of Canada. John authored 26 publications during that time and his special interests in the Poaceae and Scrophulariaceae were evident in his published works. John published five new nomenclatural combinations while at the Field Museum. He also wrote three articles on the flora and vegetation of the Canadian Northwest Territories.

John left the Field Museum to become Associate Professor and later Professor of Biology at the University of Southwestern Louisiana, Lafayette (USL) from 1961 to 1973. At USL, he sponsored undergraduate research projects, and directed six M.S. theses and one Ph.D. dissertation. During this period, John conducted most of his personal research in the southeastern United States, with an emphasis on the Louisiana flora. At USL, he authored or co-authored 47 articles. John named four plant species new to science that he discovered in Louisiana: *Cyperus brevifolioides* Thieret & Delahoussaye; *Cyperus louisianensis* Thieret; *Isoetes louisianensis* Thieret; and *Limnophila* × *ludoviciana* Thieret. From his work at USL, John published 11 nomenclatural combinations. He also published his first two generic flora treatments of the southeastern United States, five more articles from his investigations in the Canadian Northwest Territories, and several new United States or North American plant records.

John made his final academic career move in 1973, when he joined the faculty at Northern Kentucky University (NKU) in Highland Heights, as Professor and Chair of the Department of Biological Sciences. The opportunity to teach at NKU, the presence of the Lloyd Library in Cincinnati, and relocating his family to live in a cooler climate, were especially appealing to him. John served as Chair until 1980 and continued as Professor until retiring in 1992, with the title Professor Emeritus of Biological Sciences.

John loved teaching and was an exemplary teacher in the classroom, laboratory, and field. His classes were challenging, enjoyable, informative, popular, and he helped many students reach their full potential. He always was available to students and colleagues for discussions about botany, academics, or just about life. John was a strong believer in providing students with actual plant specimens, either fresh or dried, for a "hands-on" approach, and he went to great effort to accomplish that goal. In the field, John's passion for botany was especially contagious and he always felt rejuvenated after a field trip with students. John generously shared his expertise and enthusiasm for botany, especially plant taxonomy, with students, colleagues, and the general public for 32 years. His exuberance, magnetic personality, and knowledge were inspirations to everyone his activities touched.

For many years, John's summer activities were focused on teaching at various biological field stations. He served as Visiting Lecturer in Botany at the Itasca Biological Station, University of Minnesota; the Oklahoma Biological Station, University of Oklahoma; the Michigan Biological Station, University of Michigan;



John's faculty photo at University of Southwestern Louisiana, Lafayette, 1972.

and the Franz Theodore Stone Laboratory, Ohio State University. John enjoyed the flora of cooler climates, and biological stations provided Mildred and his children (Robert, Nancy, Richard, Jeffrey, and Jennifer) new environments to experience. He also conducted major field travels in the southeastern, southwestern, and northwestern United States, the Great Basin of Nevada and Utah, and the Canadian Arctic, Newfoundland, and Ontario.



John with Fraser magnolia in West Virginia during 1998 (D.M. Brandenburg).

John authored or co-authored with other botanists, 58 refereed journal articles at NKU. He frequently collaborated in research activities and publications with current and former undergraduate and graduate students and younger NKU colleagues. Indeed, he was a mentor whose enthusiasm was con-

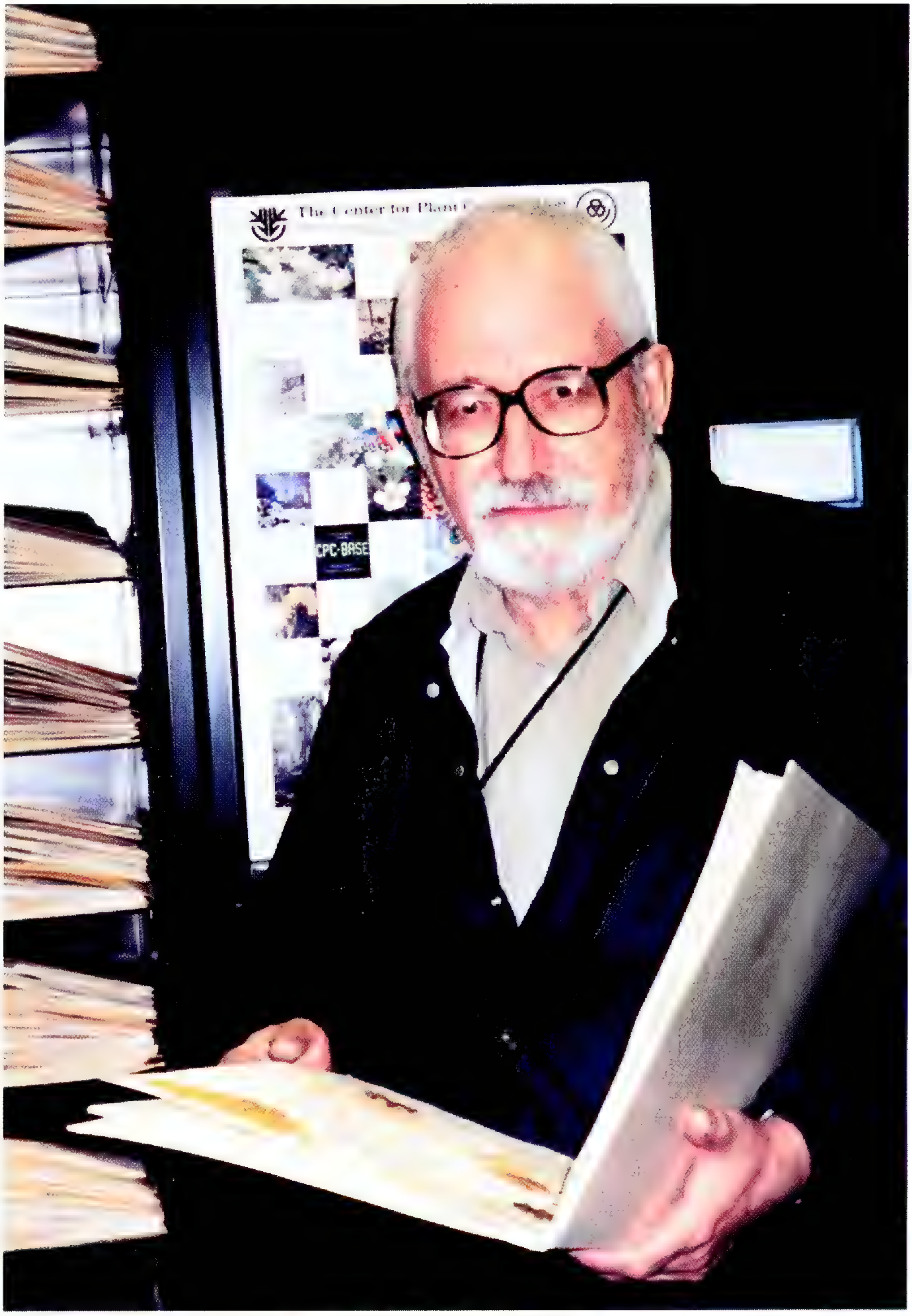
tagious and inspired botanists from many other institutions to pursue research activities. The scope of his collaborative research ranged from investigations in Kentucky, research elsewhere in the United States, to the massive North America flora project. John was the prime mover and inspiration of the Kentucky flora project, which culminated with the publication of Ronald L. Jones' *Plant Life of Kentucky* in 2005. John served as Editorial Associate and contributed the treatment of the Poaceae for this comprehensive flora.

During his tenure at NKU, John was the author or co-author of five books. These books were entitled: *Louisiana Ferns and Fern Allies*; *Aquatic and Wetland Plants of Kentucky*; *Trees: A Quick Reference Guide to Trees of North America*; *Assessment and Management of Plant Invasions*; and *National Audubon Society Field Guide to North American Wildflowers: Eastern Region*. His books continue to serve many audiences, from professional botanists to amateur plant enthusiasts.

One of John Thieret's crowning achievements was establishing the Northern Kentucky University Herbarium (KNK) in 1973. As its first Director, he built the herbarium from his personal collections, additions by colleagues and students, and through an active specimen exchange with various national and international herbaria. Currently, KNK has over 35,000 mounted specimens with strong representation from Kentucky, the Southeast, and the Midwest. The KNK collection has the highest species diversity among Kentucky herbaria collections. Through his efforts, the KNK herbarium has become the best-curated herbarium in Kentucky. John donated his entire 600 book reference library to the herbarium to further support botanical research.

John was a consummate field botanist whose excellent field abilities and extensive experiences were essential components of his accomplishments. He had an incredible memory for all of the plants that he had ever encountered and would make accurate field identifications even if he had seen the plants only once from several decades ago. This lifetime inventory combined with an amazing eye for detail enabled John to locate species that others would pass. John made an astounding number of new state, regional, United States, and North American plant records during his career. Most contemporary alpha plant taxonomists concentrate their study on a few groups, write floras at the local or state level, pursue floristics, or other taxonomic works. John was one of the last of a rare and remarkable group of field naturalists whose breadth and depth of knowledge of botanical life throughout the United States and Canada was unparalleled in his later years. He was an ardent plant collector throughout his professional career with specimen accession numbers over 62,000. John accurately identified all plants he deposited into various herbaria and meticulously mounted his own plant specimens.

John Thieret was an internationally known botanist, excellent educator, wise scholar, and gentleman. He dearly loved his family, and after family, his



John in the NKU herbarium, one his crowning achievements at Northern Kentucky University.

great passion was plants. Although John was focused on plant taxonomy and learning new plants his entire life, he had other diverse interests including classical music, particularly opera. He also enjoyed sharing his knowledge far beyond botany and the natural sciences through verbal discourse about diverse topics in history, literature, art, religion, and the social sciences.

Scientists often are judged by the number of articles by them or about them. If this is any measure of a person, John stands taller than a coastal redwood. During his professional career, John authored at least 157 refereed journal articles and book articles. Forty-two articles appeared in *Sida, Contributions to Botany*, which was his favorite journal. He also regularly published in *Bartonia, Canadian Field-Naturalist, Castanea, Economic Botany, Journal of the Arnold Arboretum, Rhodora, Taxon*, and *Transactions/Journal of the Kentucky Academy of Science*. In addition to books, journal articles, and 19 nomenclatural combinations, John wrote 136 book reviews, 65 articles for *Encyclopaedia Britannica*, 46 articles for *Encyclopedia Americana*, and many popular science articles.

John served several significant editorships and advisory roles during his professional career. He was a Member of the Editorial Board of *Economic Botany* from 1959–1965, Book Editor of *Economic Botany* from 1959–1984, Editor from 1986–1990, and Associate Editor from 1992–2002. He was a founding Member of the Editorial Board for the Vascular Flora of the Southeastern United States project from 1981–2005, and wrote seven southeastern generic flora treatments.

John served as the Associate Editor of *Sida, Contributions to Botany*, from 1972–2005, and contributed to its excellence and prestige through his dedicated work. Barney L. Lipscomb, current Editor of *Sida*, Botanical Research Institute of Texas, notes, "John was a towering lighthouse to the editors of *Sida*. His steadfast editorial, 'light,' was a never ending source of guidance and navigation in keeping *Sida* on a positive course."

From 1981–1995, John served as Abstract Editor of *Transactions of the Kentucky Academy of Science* (TKAS). He then assumed the position of Editor of TKAS in 1996 and changed the title from *Transactions* to *Journal of the Kentucky Academy of Science* (JKAS) in 1998 to better reflect its content. Through his efforts, John greatly enhanced the stature of the JKAS as a multi-disciplinary journal of state and regional scientific literature.

During 1983–2005, one of his most significant roles was serving as a Member of the Editorial Committee of the monumental multi-volume project, *Flora of North America North of Mexico*. He edited the first 10 published volumes and prepared 25 family and generic treatments. John also was an Advisor in Botany for *Encyclopaedia Britannica* from 1959–2005 and a Member of the Advisory Committee at the Lloyd Library in Cincinnati from 1992–2005.

John loved editing and his ability as an editor was extraordinary. He was a perfectionist and a superlative editor second to none, but his efforts always brought out the best in authors. Those who submitted manuscripts for John's

editorial scrutiny often found them returned with a profusion of red ink on the printed text. When his recommended changes were made, the greatly improved manuscripts always told the story better.

John received many awards and honors during his career. One of his most esteemed honors was having a mint in the Lamiaceae that he discovered in Louisiana named for him. In 1964, botanist Lloyd H. Shinners named this new species *Scutellaria thieretii* Shinners.

He received the 1984 Distinguished Kentucky College/University Scientist Award from the Kentucky Academy of Science for his significant academic research and teaching contributions to the Commonwealth. John was recently presented the 2005 Outstanding Academy Service Award from the Kentucky Academy of Science for his outstanding editorial contributions to the JKAS.

To commemorate his contributions to the Northern Kentucky University Herbarium, it was officially renamed The John W. Thieret Herbarium by the Northern Kentucky University Board of Regents on 22 March 2006.

In 1994, he established The John W. Thieret Research Award as an annual award to the NKU biological sciences student who accomplished the most significant research. The Thieret family would like to continue this student honor, and have asked that donations in his memory be sent to the Northern Kentucky University Foundation, designated to that research award.

John is survived by his devoted wife of 55 years, Mildred Thieret, his five children, Robert, Nancy, and Jeffrey in Minnesota, Richard in China, and Jennifer in Kentucky, seven grandchildren, and five great-grandchildren.

John Thieret was one of the patriarchs of North American plant taxonomy, and one of the last great field naturalists of the 20th century. His death marks the ending of a botanical era, but his legacy continues through the work of many former students and colleagues. John was an inspiring and stabilizing mentor who enriched the lives of those who knew him. He will be greatly missed by all.

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JOHN W. THIERET, THE CURATOR

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John Thieret's complex and remarkable personality had a way of leaving its mark on all who encountered him; those who met John and came to know him even briefly have rich and lasting memories of him. I am the one who, in many ways, had to step into John's shoes soon after his retirement from Northern Kentucky University, where I began my academic career in 1992. Of course, I could never fill John's shoes, and I soon learned to tell my new-found NKU colleagues on first meeting them that I was occupying the position John had vacated, but I was not John's "replacement." Most of the time, I received knowing chuckles in response to such a self-introduction.

Occupying the academic appointment John had held also meant I was the first to assume a curatorship for the herbarium that John built. After his arrival at NKU in 1973 as Chairman of the Biology Department, John lost no time in establishing a herbarium there. During my tenure as curator at NKU, John remained very active—in effect, John and I served as co-curators of the herbarium for nine years, to my great benefit. This relationship makes me uniquely qualified to remember John The Curator, a side of John to which I will limit the rest of my remarks.

John strove for excellence in everything concerning the NKU Herbarium. He put his heart and soul into collecting, identifying, labeling, mounting, and filing plant specimens in the herbarium. Though he collected far more specimens than most botanists (in the several tens of thousands), he was never in competition with others to beat their collecting records. Rather, he was interested, above all, in quality over quantity. Instead of complaining about the tedium of pressing plants, typing labels, or gluing specimens on mounting paper, John took sincere pleasure in executing these tasks that many field botanists foist on assistants. Once a specimen was in the herbarium, he insisted on the highest standards for its curation. Many times when I hosted visitors to the NKU Herbarium, or I traveled to use other herbaria in Kentucky, I heard the remark that the NKU Herbarium was the best curated herbarium in the state of Kentucky. Within a short time, I came to see for myself that this statement was true.

John had a photographic memory, which served him very well as curator. I can best illustrate John's memory by relating an experience that continues to

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amaze me. In the late spring of 1996, John entered the herbarium the day after I had returned from a long field trip through the southeastern United States for my research. John found me puzzling over a specimen I had collected. Though I was familiar with most flowering plants present in the springtime in deciduous forests of the Southeast, I had found something in one Alabama forest that completely stumped me. I had never seen this species, didn't know its family, and couldn't even be sure it was a monocot, though I somehow thought so. Turning to John, I admitted that I didn't know where to begin with this one, but suspected it was something "really good." After all, what else could I say to cloak my ignorance? John gazed at my find, hesitated only a moment, didn't say a word, and marched to one of several bookcases present in the herbarium. There, he removed one issue of one of the many scientific journals for which we had long series. Soon, he produced a photograph, and asked me, "Is this your plant?" With that photograph (Whetstone 1984: 133), I realized I had found the rare *Croomia pauciflora* (Nutt.) Torr. of the obscure family Stemonaceae. In response to my query if he had seen the plant, John responded, "No, but I remembered seeing that photograph appear in this paper many years ago."

When it came to desiderata for the herbarium, John was utterly ecumenical. Whether the lowliest, most inconspicuous, most downtrodden weed or the loftiest tree, John was interested in learning its name, how to identify it, whether it was poisonous, and if he had any specimens of it in the herbarium. His enthusiasm was infectious and quickly endeared him to other naturalists, particularly in the field. When he encountered a plant species he hadn't seen in several years, he would treat the plant as if he'd run into a long-lost friend. My most recent field trip with John was last April, when he came to Delaware for a brief visit. I insisted on taking him to a nearby racetrack that was full of vernal weeds in all their unmown glory. Within minutes, John showed me *Sibara virginica* (L.) Rollins, a mustard species he knew well from Kentucky. Further investigation showed it to be previously undocumented for Delaware, though botanists have been hunting green treasure in this state since the earliest 1800s. Such was all in a day's work if your combination of vast knowledge, keen eye, and unclouded memory were what made John Thieret the unparalleled botanical talent he was.

John was very generous with imparting knowledge it had taken him years to amass. From him, I learned a tremendous amount, and have benefited immensely. Though John could be demanding, uncompromising, and prickly at times, he was also uncommonly human. So often when I expressed frustration at ill-prepared students, particularly ineffectual bureaucracy, or the insufficiency of a 24-hour day, John would sigh and remark, "In a hundred years, no one will care a thing about it." Yet, he cared about curation, cared about herbaria, and cared especially deeply for the NKU Herbarium, one of John Thieret's great legacies. Hopefully, in a hundred years, people will care about John.



John Thieret collecting herbarium specimens, Elko County, Nevada, 11 August 1993.

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JOHN W. THIERET, A STUDENT'S PERSPECTIVE (1967–2005)

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It was a sad day 7 December 2005 when I was going through my e-mail and had two from Ron Jones. The first one indicated that John Thieret had suffered a massive brain hemorrhage, and the second one indicated that he had passed away. I immediately called Mrs. Thieret to offer her my condolences. I pointed out that I am now retired and live in rural North Louisiana. Consequently, I check my e-mail less often than while I was still a professor. Thus I had just learned of his illness. That was, by the way, the day he had passed.

My first time to meet John Thieret was March 1967. I was in my final semester at Louisiana Tech, and he and I had agreed for me to attend The University of Southwestern Louisiana (now University of Louisiana at Lafayette), where he was then employed, and to study under his direction for a master's degree in plant systematics. Dr. Thieret at the time had a grant from NSF to prepare a Flora of Louisiana. Howard Clark, a graduate student at the time, and Dr. Thieret came to Louisiana Tech and took me on a weekend field trip to Northeastern Louisiana. We met about 6:00 a.m. at Carson Taylor Hall, the building that housed the Botany and Microbiology Department. Dr. Thieret had a truck with a camper that would sleep three people, which he had purchased with the NSF monies. In the rear of the camper were a few plants of flowering *Sanguinaria canadensis* (Papaveraceae), which they had collected the previous afternoon. That was my first time to see the species other than by herbarium specimen.

During our weekend field trip, we visited quite a few beautiful deciduous forests, most with spring wildflowers. In particular we found *Trillium* (Liliaceae) (I cannot remember the species, and I am sure that John Freeman has since named that one differently than what Thieret would have called it). Again, that was my first experience with *Trillium*. The manner we used for locating good collecting habitat was to examine topographic maps and find areas with considerable relief. I thought at the time that we were quite fortunate in locating habitat. Since then I have learned much about field work, and I know that an excellent field botanist, such as John Thieret, has a sense for determining from topographic maps where good habitat might be.

I began to learn the personality of John Thieret that weekend. He was con-

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stantly smiling, making jokes, telling stories, and teaching. From that weekend to the day he died, he was always teaching whenever I was in his presence.

George Fisher, who was a graduate student at Tech in 1967, and I went to Lafayette later that spring for a collecting trip to the Florida parishes with Thieret. I realized more about his practical jokes early on that trip. We followed his directions to the USL campus and Biology Building where he was awaiting our arrival. He asked us to follow him to his house where his camper/truck was parked. He started home and took us through more back roads (all dirt) than one can imagine. When we arrived at his house (on a paved road of course), he got out of his car laughing saying he just wanted to have some fun. By following the paved road, one could get from the USL campus to his house in half the time it took us!

The Florida parish trip had a profound effect on my botanical career. In western Washington Parish, we collected a pondweed that Thieret called *Potamogeton nodosus* (Potamogetonaceae). I did not question him at all. During my first semester at USL, Dr. Thieret brought out the specimen and asked me to determine it. I said you called it *P. nodosus*. He said that now he was not certain about that determination. I keyed out the specimen and consistently arrived at *Potamogeton epihydrus*, which was not supposed to be in Louisiana. I looked at the distribution, and it was known no closer than North Carolina at the time. I went to him, and he said that is what he determined the specimen to be also. That began a lifelong study of the genus *Potamogeton*.

The fall of 1967 I entered the graduate program at USL. Dr. Thieret had three other graduate students at the time, Howard Clark, Alex Lasseigne, and Billy Dan Hinton. Howard was working on the Lemnaceae of Louisiana, Alex was studying the Fabaceae (we called it Leguminosae at the time) of Louisiana, and Billy Dan was studying *Parietaria* (Urticaceae). I have always been interested in aquatic vascular plants, and my plans were to undertake a study of *Utricularia* (Lentibulariaceae) of Louisiana. Dr. Thieret began going through his literature and correspondence and learned that Peter Taylor of Kew had undertaken a study of *Utricularia* of North America and he, Dr. Thieret, did not want me to duplicate any study underway. Therefore, my future in the Lentibulariaceae came to an abrupt end. We talked about several genera, none of which really interested me, and we finally settled on *Conopholis* (Orobanchaceae), a genus as far from the aquatic environment as possible. As everyone who knows me is aware, I never really left the aquatic environment, however.

Dr. Thieret had all of his graduate students work in the herbarium, and, current graduate students would find this hard to believe, without pay. We mounted and filed specimens, pulled specimens for loans, etc. As it turned out, I became the unofficial collections manager. I had closer interactions with Dr. Thieret than others for that reason. Of course, I always received the blunt of any rage if things did not go just right, even if it was totally out of my control.

John Thieret loved classical music! He had a phonograph (tapes and CD's did not exist then!) that played in the herbarium much of the time, and he often placed it on one of the herbarium carts and played it in class. Thieret could whistle quite loudly, and he often was going around the biology building whistling classical music.

Thieret suffered from occasional migraines, and, as I am sure most people with migraines, he was quite moody when he had a migraine. Whenever he was having a mood swing as a result of a migraine, he whistled exceptionally loudly. We graduate students learned to get out of the way whenever we heard that extremely loud whistling. In fact, if I was unusually late arriving in the morning and heard that whistle, I just went right on out of the building to a grill that was just off campus. All other graduate students had learned the routine, and we all met at the grill for coffee until we thought the whistling had ceased. (I told him about our coffee excursions during a trip he and I made out West in 1998. He was totally unaware of these excursions, or so he said.)

Without question, John Thieret was an editor, an excellent editor. I never will forget the first draft of my thesis. I proudly gave it to him, and it soon returned looking as if a chicken had stepped into red ink and then walked all over my manuscript! I learned from him to be much more careful when writing and speaking. He had many favorite sayings, but one that I remember very well was related to editing. It is "consistency is next to godliness." He said, be consistent; if you are incorrect at least be consistently incorrect!

I learned much botany from John Thieret, but one thing in particular was that he did not like the term "pistil." He said that it was an ambiguous term and that carpel was a much better term. I adopted his argument and never used or taught pistil after that. In courses that I taught, I always had to explain to the students why I did not use the term pistil regardless that it was in the text. John Thieret eventually became an editor for Flora of North America, and the editorial board adopted the term pistil over carpel. I am sure it was difficult for him to accept such a change, but he did. As it turned out, he was the taxon editor for the families that I contributed to FNA. He had to fight with me to get me to use the term pistil. I told him why, he agreed, but he said his hands were tied. I told him I was not going to type in the word pistil, but he was welcome to replace carpel with pistil in my manuscripts, which he did reluctantly.

One of the courses that Thieret taught at USL was Plant Ecology. I had previously taken such a course, so I did not take it from Thieret. He decided to take the students on a field trip to Western Texas and Eastern New Mexico. He had never been to that area, but I had been there several times, as my in-laws lived in Eastern New Mexico at the time. He asked me where to see habitats, and I told him several areas that would be good. Rather than attempt a trip on his own, he asked me to serve as a guide on the trip. I agreed, and we headed west. We were in the desert scrub west of Sanderson, Texas one afternoon where he

was talking to the class about *Ephedra* and other desert scrub plants. I had moved away from the class and was examining closely some *Ephedra* plants, when he started the class back toward the car. He was moving at his normal pace "full steam ahead and damn the torpedoes" when I heard an awful scream from him. I was 25 feet or more behind the class when I caught him running! He had walked upon a Western Diamond-back Rattlesnake! It was coiled under some scrub, and he had almost stepped on it. We stood still (after I settled his nerves) and watched the snake for a few minutes. It finally began to move, and crawled across our path. That was the longest snake that I have ever seen, or so it seemed at the time.

Dr. Thieret wanted to show the ecology class, in addition to desert scrub, mountain vegetation, terminating with tree line and above. He asked if such existed in southern New Mexico, and I said I could take him above tree line. He thought it was too far south, and, as he often did, would occasionally throw some joking jabs into the conversation indicating his disbelief. We started toward Ruidoso, New Mexico, where I knew there was a ski resort and the mountain went above timberline. As we turned a curve and the mountain came into view, with the alpine tundra and snow cap, he immediately said, "I told you it was here, you just would not believe." Of course it was a joke, and he used this phrase very often. Unfortunately, the ski lift was closed for the season, so we had to climb up one of the ski runs to timberline. We did so, and enjoyed collecting in the alpine tundra, the first time that I actually ever went above timberline.

Howard Clark and Billy Dan Hinton graduated my first year at USL. David Dike came to USL as a graduate student during my second year, and he chose to study the life history of *Ottelia alismoides* (Hydrocharitaceae), a species introduced from Southeast Asia. The species was known to occur in The Pool, Lacassine National Wildlife Refuge, south of Lake Charles, LA. Dr. Thieret, David, and I went to Lacassine to plan his study. We were in a small boat in The Pool and were being blown rapidly by the wind. I saw something in the water that I did not recognize and made a grasp at it as we were blown by. Remarkably, I grabbed the plant and enough of it was uprooted to make a couple of specimens. I looked at the specimen and had no idea what it was. I gave it to Dr. Thieret, and he, too, had no idea what it was. We placed it in a bag and took it back to the lab, where, using *Aquatic Plants* (of India), I quickly determined it as *Blyxa aubertii*. (Hydrocharitaceae). We had gone to study one introduced aquatic from Southeast Asia and had found a second. We prepared a manuscript to report the species new to North America, which appeared in SIDA later that year. Dr. Thieret sent a duplicate to MICH as a gift, and Ed Voss sent back a letter stating that was the first record from the Western Hemisphere of *Blyxa* in their herbarium. Thieret immediately sent back a letter indicating that it was our first record also (always a practical joker!).

John Thieret mastered a technique for rapidly pressing specimens and re-

cording the data. While he was working on a Flora of Louisiana, he was collecting abundantly all over the State. He had us graduate students (usually me) prepare his pressing papers. All papers were separated and carefully folded. Any that had color printing must be discarded as the color could get on the plants and affect the corolla color. He had the carpentry shop on campus prepare him a box with two compartments, each compartment slightly larger than the size of a folded sheet of newspaper. This box was a permanent fixture in the rear of the camper mentioned above.

We graduate students were to divide the folded newspaper into two stacks, one on which we stamped his collection numbers and the other without numbers. We used the herbarium numbering machine to stamp his collection numbers on the paper. The numbered stack went into one side of the box, and the unnumbered stack went into the other side. In the field we would collect a batch of specimens and stack them beside the box.

Thieret always pressed his collections within a few minutes following collecting. After a short time following collection, he would say, "we have a pressing engagement." That meant it was time to press plants. He had a tape recorder that he used to record the data, and this tape recorder always rode in the box, with the newspaper serving as padding for it. He would stand in front of the box of papers, record the collecting locality and habitat data, get a numbered paper from top of the stack, read that number into the recorder, record the species name, and finally record any specific information about the specimen. The first individual was pressed in the numbered paper, and all duplicate specimens were pressed in unnumbered papers. It was always this sequence (consistency!), so keeping duplicates with the correct number even though they were in unnumbered papers was easy. The field pressing was in a field press, composed of six or seven cardboards cinched with a press strap. The full field press stayed in the truck the remainder of the trip, and we transferred specimens to a permanent press upon returning to the lab, often four or five days later.

For the evening, we would park wherever he could find acceptable and spend the night. This place may be a roadside park (illegal in Louisiana, but with State plates he always got by with it), state park, etc. One of his favorite places to spend the night was a rural cemetery. He said that no one visited these cemeteries at night, and he would not be bothered. I do not think he ever was. Each night in the field, all of the recorded data were transcribed. He had a portable typewriter that stayed in the camper, and he would type all data of that day into his loose-leaf field notebook. The recorder then was ready for the next day. Once back at the lab, he had a secretary type labels using his typed field notes. All duplicate labels were photocopied, a practice that probably was not advisable with technology of the day. Also once back at the lab the process of moving specimens from field press to permanent press began. Again, consistency was important here! One would always begin at the TOP of the field press,

never the bottom. (Remember here the numbered paper went into the field press first, followed by unnumbered papers.) Starting from the top, then the unnumbered papers would go into the press first for a particular collection, with the final sheet of a collection being numbered. Consequently it went on top for that collection number. After all specimens were transferred to permanent presses, then the presses were placed on the driers, which were in the work area of the greenhouse. Removing the specimens from the permanent press also required consistency. Always start from the TOP, never the bottom. As the press was disassembled, the first paper out was numbered, usually followed by one or more unnumbered papers. These unnumbered papers went inside of the numbered one until another numbered paper arrived. This process was repeated until all specimens were out of the press. Using this procedure, regardless if the same species immediately followed itself, the duplicates always stayed together. After the presses were broken down, the specimens were all placed in a cabinet for unmounted specimens.

Collections he made for the Flora of Louisiana project were used as exchange specimens for the USL herbarium (LAF). Once the unmounted cabinet was full or nearly so, which was once or twice a year, he and I would begin the process of deciding where to send duplicates. He exchanged with 15 or 20 herbaria. We would spread out the numbered paper followed by all of the unnumbered ones of a collection. The best specimen would go into the LAF stack, and then all others were sorted into one, two, three, four, etc. stacks, one sheet per number per stack, one stack per exchange herbarium. The original label went in the sheet for LAF, and photocopies went with the duplicates. It was my responsibility to get the duplicates all boxed, shipping labels and invoices prepared, and get the specimens to the post office.

With us sending out thousands of exchange specimens each year, we also received thousands of exchange specimens in return. Thieret and I often made a game of opening the exchange boxes. We would turn the stack so that the labels were face down and both stand there in anticipation. One of us would quickly open the top newspaper, and our game was to see which one could say the name first. He usually won, but I did occasionally – he probably just let me win, however.

After I graduated from USL, I attended The Ohio State University, where I earned my Ph. D. under the direction of Dr. Ronald L. Stuckey. While I was at Columbus, Dr. Thieret was hired by Northern Kentucky University, in Alexandria, KY to be Chairman of Biological Sciences.

John Thieret believed in precision. He always said he was easily pleased with perfection. Once I had completed my Ph.D., Dr. Thieret invited me down to give a seminar at NKU. Since he had known my wife and son while we were in Lafayette, he invited us to stay at his home in Alexandria. He sent directions that stated after crossing the Ohio River in Cincinnati continue south until in-

tersect State Route 27. Then follow State Route 27 to Alexandria. After we crossed the Ohio River, we noticed U. S. 27 a mile or so from the bridge. I told my wife that Dr. Thieret was so precise that he certainly did not mean U. S. 27 since he clearly stated State Route 27 (we had his directions in hand!). We continued south and finally gave up, deciding that he must have meant U. S. 27, which he did. We turned around, found U. S. 27 and followed his directions onto campus. He was outside the Biology Building frantically awaiting our arrival, since it was less than 30 minutes before the seminar was scheduled to begin. His history of precision almost upset the applecart.

I saw Dr. Thieret only occasionally after I left Lafayette, although we always kept in touch. Following the start of FNA, where I ran across him mostly was at the Missouri Botanical Gardens, as he was always there just prior to the annual Systematics Symposium for a FNA editorial meeting. In July 1998, he and I made a two week collecting trip to Utah and Nevada. We agreed that I would drive my Jeep SUV and that I would pick him up at the St. Louis airport. I was to bring all of the collecting equipment and floras since I had much more room than he would have. When I met him at the airport, I was surprised to see that he had one small shoulder bag for a two week trip. I asked about his luggage. He said this is all I have. Needless to say, I could not image how he was going to get along for two weeks with just that in the small bag (certainly no larger than 3 inches by 9 inches by 15 inches). He said it was less expensive for him to fly from Lexington to St. Louis than from Cincinnati to St. Louis, regardless that the plane leaving Lexington stopped in Cincinnati prior to arriving at St. Louis and similarly on return. So Mrs. Thieret drove him to Lexington where he caught the plane and flew to St. Louis. His plans were to exit the plane in Cincinnati on the way home rather than go to Lexington. He obviously could not get his luggage if it was checked to Lexington, so he had to take aboard everything he needed. I still am amused about his reasoning, although it worked. We had a wonderful time in the mountains and deserts. I collected many aquatics, and he collected many grasses (all under my numbers). I bet my friends who know I almost never collect grasses could not imagine why so many appeared under my numbers! Regretfully, the last time I ever saw him was when I left him at the airport in St. Louis after that wonderful two weeks. I did talk with him occasionally, and we did often exchange e-mails, but I was never in his presence again.

I regret that we were unable to get together for eight years prior to his death. We had planned another collecting trip, this one to Northern Minnesota. My mother, however, became seriously ill, and we had to cancel that excursion.

Few people have affected my life the way John W. Thieret did. We certainly had some rocky times when I was handling the herbarium at USL, but we had many, many wonderful times together, which completely obliterate any rocky times we might have had.

JOHN W. THIERET, VALUABLE BOTANICAL FRIEND (1965–2005)

Ronald L. Stuckey

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John W. Thieret was one of my valuable botanical friends, and his loss through death is now clearly becoming a reality. I received notice of his death on 7 December 2005 from a short morning telephone conversation from his zoological colleague, Tom Rambo of Northern Kentucky University. Tom has been known to me since his graduate school days when he was studying ornithology. We were together during summers at The Ohio State University's Franz Theodore Stone Laboratory Biological Field Station in western Lake Erie on Gibraltar and South Bass Islands, at the town of Put-in-Bay, Ohio. My recollections of John Thieret are based on facts that I have obtained from my correspondence with him, students of mine that have taken his Field Botany class that he taught at the Stone Laboratory, my interactions with him as an editor for *Sida* and book review editor for *Economic Botany*, and other recollections I have of him during our 40 years of working together.

In 1965, I had completed my doctoral dissertation on *The Taxonomy and Distribution of the Genus Rorippa (Cruciferae) North America*, a group of yellow-petaled plants in the mustard family, commonly referred to as marsh cress. I received the Ph. D. degree at graduation on 1 May 1965 at the University of Michigan, Ann Arbor, and arrived in Columbus in September of that year to begin my career as an assistant professor of botany at The Ohio State University. I believe I had heard of the name John W. Thieret, as a botanist who had been in the Chicago area, but now was teaching and conducting research at the University of Southwestern Louisiana at Lafayette.

John W. Thieret, *Rorippa*, and Ronald L. Stuckey (1965–1966)

A letter dated 3 December 1965 arrived addressed to me, the short text which stated:

> We note with interest that you are carrying on work with *Rorippa*. May we send to you our specimens of this taxon for annotation? Most of the material in our herbarium consists of Louisiana plants collected during extensive field work over the past several years in connection with our state flora project.

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I responded on 7 December (exactly 40 years earlier on the same day of his death) telling him that I would annotate his specimens of *Rorippa*, and on 28 January 1966 I signed the loan form for 31 specimens and one to retain. Upon returning the loaned specimens, I wrote in my letter to him of 1 March 1966 offering to write a key to the species of *Rorippa* that grow in Louisiana, as John was preparing a flora of that state. I also noted that my dissertation was not yet published, and therefore some new names and/or combinations were not yet valid. John's immediate reply of thanks for my annotations on the specimens was received a few days later. The letter concluded with "Let us know if we can ever be of help to you. We are always willing to loan or to try to collect specimens for those who ask..."

John W. Thieret and Robert R. Haynes (1968–1969)

Robert R. Haynes was a graduate student of who worked in the Herbarium under John Thieret's direction. Bob also earned a masters degree at the University of Southwestern Louisiana, Lafayette with a thesis, titled "A Monograph of the Genus *Conopholis* (Orobanchaceae)," completed in May 1969. Robert was really more interested in aquatic vascular plants, and he wanted to study pondweeds in the genus *Potamogeton* but, of course, no Ph. D. program was offered in biology or botany at the University of Southwestern Louisiana. He sought Thieret's advice, who told him that a young professor by the name of Ronald L. Stuckey in the Department of Botany at The Ohio State University might be a place where he could study these narrow-leaved pondweeds.

Robert R. Haynes, *Potamogeton*, and Ronald L. Stuckey (1968–1973)

Bob's first letter dated 12 October 1968, came to me with the following request:

> This spring I hope to receive a Master of Science degree from the University of Southwestern Louisiana. I plan to begin work this summer toward a Doctor of Philosophy degree in plant systematics and am considering Ohio State University as a possible school. My main interests lie in aquatic plants. Preferably, I would like to do some biosystematic work in the genus *Potamogeton* subsection *Pusilli*.
>
> I am writing to inquire if there is any possibility of working under your direction and of obtaining the financial aid that will be necessary if I am to continue my studies.

By this time Bob had in press his paper on the "*Potamogeton* in Louisiana" (*Proc. Louisiana Acad. Sci.* 31: 82–90. 1968). The first paragraph of my reply to Bob on 22 October 1968 stated:

> It is a pleasure to learn of your interest in beginning a program toward a Doctor of Philosophy degree in plant systematics at The Ohio State University. I am also pleased to learn of your interests in aquatic plants, particularly in the genus *Potamogeton*.

My letter continued explaining that I was "primarily interested in floristic and phytogeographical problems in aquatic and shore plants." I acknowledged that his interest in aquatic plants would fit into our program. I mentioned the avail-

ability of teaching assistantships, and asked Bob that he send a summary of his course work, his graduate Record Examination Scores, and asked the Graduate School Admissions Office to send him application forms and instructions. John W. Thieret's letter of recommendation for Bob's graduate work has not been located and probably no longer is extant. Bob's application for Graduate School, after review by the Graduate Committee in the Department of Botany, initially was not favorable for accepting him. John W. Schmit, chairman of the committee and I, with the permission of the Committee, agreed to give Bob a trial period, and asked him to enroll in the 10-week summer field program, taking a maximum of four courses at the Franz Theodore Stone Laboratory. Bob completed this work during the summer of 1969 and earned A's in all four courses. He then returned to Louisiana where he was a teacher at Cecila Jr. High School in Cecila.

In the fall of 1969, Department Chairman Schmitt and College Dean Richard H. Behning agreed that I needed more permanent help with my responsibilities as Curator of The Ohio State University Herbarium. The position of Assistant Curator was established. The first person appointed to the position had to leave at the conclusion of the fall 1969 quarter, and with the position vacant, I called Robert R. Haynes to see if he would accept that responsibility. From February 1970 to June 1971 he was the Assistant Curator in the OSU Herbarium, and from September 1971 to June 1973 he held teaching assistantships. Bob completed his dissertation in June 1973 on "A Revision of North American *Potamogeton* Subsection *Pusilli* (Potamogetonaceae)," which was published in *Rhodora* 76: 564–649. 1975. Bob remained in Columbus at The Ohio State University for the academic year 1973–1974 and was an instructor in botany teaching General Botany for three quarters and Local Flora during the summer quarter.

Bob developed a career as a professor teaching plant taxonomy, advising graduate students, curating a herbarium—all of which concluded with his retirement in May 2005 from the University of Alabama, Tuscaloosa. His major work on *Potamogeton* and related genera is published in the *Flora of North America North of Mexico*, Volume 22: 3–94. 2000.

John W. Thieret and the Stone Laboratory (1970–1971)

In 1956 a new summer teaching program was developed at the F.T. Stone Laboratory under newly appointed Director Dr. Loren S. Putnam, ornithologist of The Ohio State University. In the new system, Dr. T. Richard Fisher of the Department of Botany taught two 5-week courses, Field Botany during the first term and Higher Aquatic Plants during the second term. I had the privilege of attending the Stone Laboratory and took the Field Botany course from him in the summer of 1959. Since that time I kept in contact with Dr. Fisher, who later was responsible for my joining the faculty of The Ohio State University in the fall of 1965. Among my responsibilities eventually was to teach at the Stone Laboratory, and that opportunity surprisingly came the following summer

when I taught Field Botany. During the 1967 season I taught the Aquatic Plants course. Then in 1968 Fisher left the University to become chairman of the Biological Sciences Department at Bowling Green State University in Ohio. Dr. Putnam, who had a budget for the courses at the Laboratory, and in agreement with chairman Schmit of the Department of Botany, chose to hire a non-OSU teacher for the Field Botany course in 1969 and 1970. That arrangement was to allow me to have more time to develop a research program studying the aquatic vascular plants of western Lake Erie, instead of teaching both courses as Dr. Fisher had done since 1956. Putnam also preferred to have non-OSU professors teaching two consecutive summers and then change to a different teacher. Putnam relied on my advice in these situations and asked whom we might hire to teach the Field Botany course during the summer of 1971. At the time Robert Haynes was the Assistant Curator of the OSU Herbarium, and I asked him for suggestions. Naturally he suggested John W. Thieret, and I reported to Putnam with this recommendation.

From Putnam I soon knew that Thieret was hired to teach Field Botany, and a letter of 9 November 1970 came to me from Thieret:

> I've just spoken with Dr. Putnam regarding Put-in-Bay next summer. I asked him to suggest someone to whom I could write concerning such things as an outline or syllabus or what-have-you for Botany 610, Field Botany; the text or texts used; class procedure; collecting localities; etc.; etc.; etc. In response to my question, he suggested your name. Thus you are the chosen victim.

John followed with four questions that concerned the course outline, the textbook used, class procedure, and good field localities to see and collect plants. In regard to the latter item he wrote:

> I must admit that I am a bit panicked by the thought of trying to find enough such localities on a small island. (A bit more limited area than I am used to at Lake Itacsa, you know. I mean "Itasca.") . . . I'm certainly looking forward to trying my hand at Put-in-Bay. Maybe I'll even be given the chance to meet you. Best wishes. And please give my regards to Bob Haynes.

My three and one-half page letter of 17 November 1970 followed. It began:

> I am very pleased to learn that you are going to be with us teaching Botany 610 (Field Botany), this summer at Stone Laboratory. Your letter of 9 November, full of questions is at hand, and I'll try to answer them as best I can. I took the field botany course at Stone Lab in 1959 and taught it once, in 1966. Since then I have been developing and teaching the aquatic plant course which meets every other summer and to develop a research program around the theme of the changing flora of the islands and of the aquatic situations that we find in the area.

My letter continued by giving John some statements about the kinds of students that take the course and their knowledge of plants. I noted that the course primarily concerned the flowering plants, that Clara G. Weishaupt's *Vascular Plants of Ohio* was the book used, and that I had an outline of the course with various procedures that I would mail him. Then I wrote a long statement about class field

trips, assuring him that he would have plenty of plants and ample places to take students. With reference to field work, I added a statement about taking field trips by boat to the various islands in Lake Erie and to the Ohio mainland.

My letter concluded with comments on the available library resources, laboratory supplies for the course, materials for pressing and drying collected plants, and the information sheets, more commonly known then as "handouts," that I used in the 1966 Field Botany course. The latter I offered to mail to him. I concluded the letter about my own projected plans for the up-coming summer.

> I will be at the Laboratory all summer myself. The first term will be for research, at which time I will be spending most of my time writing. Hopefully, I can finish the manuscript on the "Flora of the Erie Islands," and make significant progress on my anticipated treatise on the "Origin, Changes, and Geographical Relationships of the Aquatic and Marsh Flora of Western Lake Erie and Northwestern Ohio." During the second term I will be teaching the Aquatic Plant course. I am looking forward very much to your coming to Stone Lab next summer. Please do not hesitate to write if you have further questions. I hope the above comments will be helpful to you.

John did not hesitate to send a return letter, dated 20 November 1970. It began, "I certainly thank you for your long letter—and all the useful data therein. Believe me, your help is deeply appreciated." After commenting on the various items I had mailed him, he concluded his letter saying, "After I've gone over all the material thoroughly, I'll let you know if any other questions arise.... Thanks a lot for all your fine help."

John continued his pursuit concerning the 1971 summer program at the Stone Laboratory, and on 19 January 1971, he wrote to Director Putnam, greeting him with:

> Dear Puttie:
> I note in your bulletin for summer 1970 that you had, in 1969 a series of talks—a "Special Lecture Series"—by "outstanding scientists." While I certainly am not "outstanding" (except in my unrivalled humility) and there are those who maintain that I am no scientist, I still intend, via this letter, to offer to give some sort of a talk this coming summer. I have done quite a bit of botanical field work in Canada's District of Mackenzie—in the Great Slave Lake region. As a result of the work, I have a set of slides that some people find interesting, especially when the slides are accompanied by the delightful commentary presented by humble John. If you wish such a presentation—let's call it a travelog—I'd be glad to import my slides to Put-in-Bay this coming June. I'm not at all certain that a travelog by JWT would be worth a mention in your 1972 bulletin, but it might fill in an otherwise empty evening on Gibraltar. And besides, I like to talk...Let me know.

This letter reveals much of the kind of humor John displayed about himself. Regarding these special lectures, beginning in the summer of 1970, Director Putnam asked me to make arrangements for the special lecture series at the Laboratory. I contacted the potential speakers, prepared the program, hosted their visit, and introduced them when they made their presentations on Thursday evenings. Scheduling a special lecture by John W. Theiret was easily accomplished, and I distributed the lecture schedule with Thieret listed for 13

July 1971 with the title "The Yellowknife Highway Region, Canada: Flora and Vegetation." John's wish to present a lecture was fulfilled, and his lecture title later was listed in the 1972 admissions bulletin.

Again, Thieret, *Rorippa*, and Stuckey (1966–1972)

When I completed my dissertation on the genus *Rorippa* in 1965, it was difficult to locate a journal that would publish a large taxonomic monograph as a single paper or issue of a journal. My advisor, Edward G. Voss, had anticipated that I could retain the entire dissertation as one unit if it were published in the *Contributions from the University of Michigan Herbarium*. This publication had been inactive for some years, and editor Rogers McVaugh reaffirmed that funds were not available at that time to reactivate it. The conclusion was that I would have to look elsewhere to publish my dissertation.

Edward G. Voss held in high regard the taxonomic knowledge of Lloyd H. Shinners of Southern Methodist University. When Lloyd taught the field taxonomy course in the summer of 1952, at the University of Michigan Biological Station, Pellston, Ed was his graduate teaching assistant and from then on grew a close botanical relationship and great respect for each other. In 1962, at SMU Shinners began publishing a private taxonomic journal named *Sida*, and Ed suggested that I might contact Dr. Shinners regarding publication of my *Rorippa* monograph. I then proceeded to correspond with Shinners about my study of *Rorippa*, and during 1966 I extracted and published two short papers taken from my dissertation. They were "The distribution of *Rorippa sylvestris* (Cruciferae) in North America" (*Sida* 2:361–376. 1966), and *Rorippa walteri and R. obtusa* synonyms of *R. teres* (Cruciferae)" (*Sida* 2:409–418. 1966). During 1967 through 1969, I revised my monograph on *Rorippa*, and on 5 December 1969, I wrote to Dr. Shinners asking if he would publish my *Rorippa* study in *Sida*. He enthusiastically responded on 9 December 1969, and told me to send the manuscript to him after Christmas. A letter of 26 March 1970 confirmed that he had accepted the manuscript, whose "bulk is a bit appalling." I heard nothing further from Shinners until I learned of his death of 16 February 1971. The future status of *Sida* was in doubt, and therefore the publication of my *Rorippa* monograph also was in doubt. Later on 15 March 1971 I wrote, I wrote Dr. William F. Mahler, who was Shinners replacement, thanking him for his letter of 3 March 1971 which indicated that publication of *Sida* would be continued and that additional work was to proceed on my *Rorippa* monograph. "I am pleased that you have selected Dr. Thieret to go over my manuscript in preparation for its publication....As you may know Dr. Thieret will be at our University for 5 weeks this summer teaching at Stone Laboratory. I will be there at the same time and can work with him on the manuscript."

In April 1971, John and I began a correspondence on the preparation of the *Rorippa* monograph for publication in *Sida*. Together, John and I discussed the

Rorippa manuscript while both of us were at the Stone Laboratory. Later in the year John wrote me letters on the progress of the editing which continued into 1972. John's letter of 11 January 1972 stated:

> When I finish with the ms., I shall return it to Mahler. I have just been asked to serve as Associate Editor of *Sida*—which is just what I've been doing all along!

By April John had sent the edited *Rorippa* manuscript to Mahler, and the latter replied to me, 13 April 1972, that my "manuscript is already at the printers." Thieret received the galley proof sheets and then sent them on to me for reading. Together that summer at Stone Laboratory, John and I read the galley sheets. Page proofs came on 25 July 1972, according to Mahler's letter to me, on 8 August 1972. I returned the final page proofs, and by 27 September, I was completing the transaction to purchase 200 copies of my study of *Rorippa*. My monograph, "The Taxonomy and Distribution of the genus *Rorippa* (Cruciferae) in North America" appeared in *Sida* 4(4):279–430. 1972. John W. Thieret was listed as the associate editor and William F. Mahler as the copyright owner. Had it not been for Thieret entering the situation, my monograph might never have been published. I owed him a great debt of gratitude for his unselfish help in editing my publication.

Again, Thieret and Stone Laboratory (1972)

In the summer of 1972, Thieret returned to the Stone Laboratory and again taught Field Botany. This summer he had prepared a book of mimeographed course handouts that were to be given to each student. Nearly everything that John wrote had some humor associated with it. At the bottom of the Table of Contents page was the notation, **HAVE YOU THANKED A GREEN PLANT TODAY?**

My masters student David L. Moore took the course from Thieret that summer. At that time also, David was studying the changes, since 1895, in the aquatic vascular plant-flora of East Harbor State Park, Ottawa County, Ohio (Completed 1973; portion published in *Ohio J. Sci.* 76:78–86. 1976). David later in 1976 earned the Ph.D. degree from The Ohio State University by studying the distribution of freshwater algae in northeastern Ohio with Dr. Clarence E. Taft. Since then David has taught botany courses in the Department of Biology at Utica College of Syracuse University, Utica, New York. Beginning in 1993, he returned to the Stone Laboratory and has taught the aquatic plants course every summer except 2005. The course was not taught that summer.

In response to my request for information about John Thieret's 1972 Field Botany class, David provided the following three paragraphs:

> As I retrieved an OSU soft cover binder from my office shelf, I was reminded of the passage of 34 years by the yellowed, brown-edged, hand-written pages! The summer 1972 Field Botany course with Dr. John Thieret came back to me as I read through the pages of notes. We learned a total of 191 taxa in those five weeks and the floral formulae for 25 plant families. Indeed it was the first time I had ever seen floral formulae and floral diagrams! My favorite plant was ***Matricaria matricarioides***, the Pine-

apple Weed, which Dr. Thieret picked by the docks and gleefully crushed in his palm so we could sniff the fragrance of fresh pineapple.

At the first class session Dr. Thieret went over the syllabus. Everyone laughed when he referred to examinations as "mental enemas." I will always remember the cover of his mimeographed course handouts which he provided to us that first day. The front page pictured **Shiva Nataraja,** the Hidu Lord of the Dance on a ***Nuphar advena*** leaf which protruded from the fruit of ***Nelumbo lutea***. In the right rear hand was a leaf of ***Rhus toxicodendron*** (Poison Ivy) while in her left rear hand was an ***Aescylus glabra*** leaf (Buckeye). The afternoon of July 8 was my first trip to Pelee Island. It was probably one of the highlights of the session, and where I first saw ***Populus grandidentata*** and ***Diplotaxis***. I still don't know if it was ***D. tenuifolia*** or ***D. muralis.***

At the end of the session, just before the final exam, Dr. Thieret read a poem he had composed on the porch of Bayview House where he and his family lived. In it he dedicates a verse to each of the students in the class. After he read it he gave each of us a two page mimeographed copy on yellow paper. I kept my copy in my notebook after we finished the course. I retyped it with the same spelling, punctuation and format that he used except that I placed it in two columns. There is one misspelling left intact - "cannister"- and the two lower case letters which should have been capitalized. All of his "poetic license was retained).

I have selected the following six verses of John's poem, titled "Botany 610 In RHYM, Summer 1972," for publication here:

Botany 610 in Rhym
Summer 1972

This is the forest primeval
The murmuring Acer and Celtis
And this is the class that beneath it
Romped cheerfully after their Leader.
This is the class below pictured
In verses rhythmic, poetic.

'Twas a pleasure to watch Mr. Moore
Whose knowledge of plants was not poor.
Like an eye-talian barber
He combs over east Harbor
And there gave Fearless Leader a tour.

And now it is time for Miss Kneller
I tried hard this plant world to sell 'er.
By selling my wares
I increased her cares.
So often "Work hard, dear" I'd tell 'er.

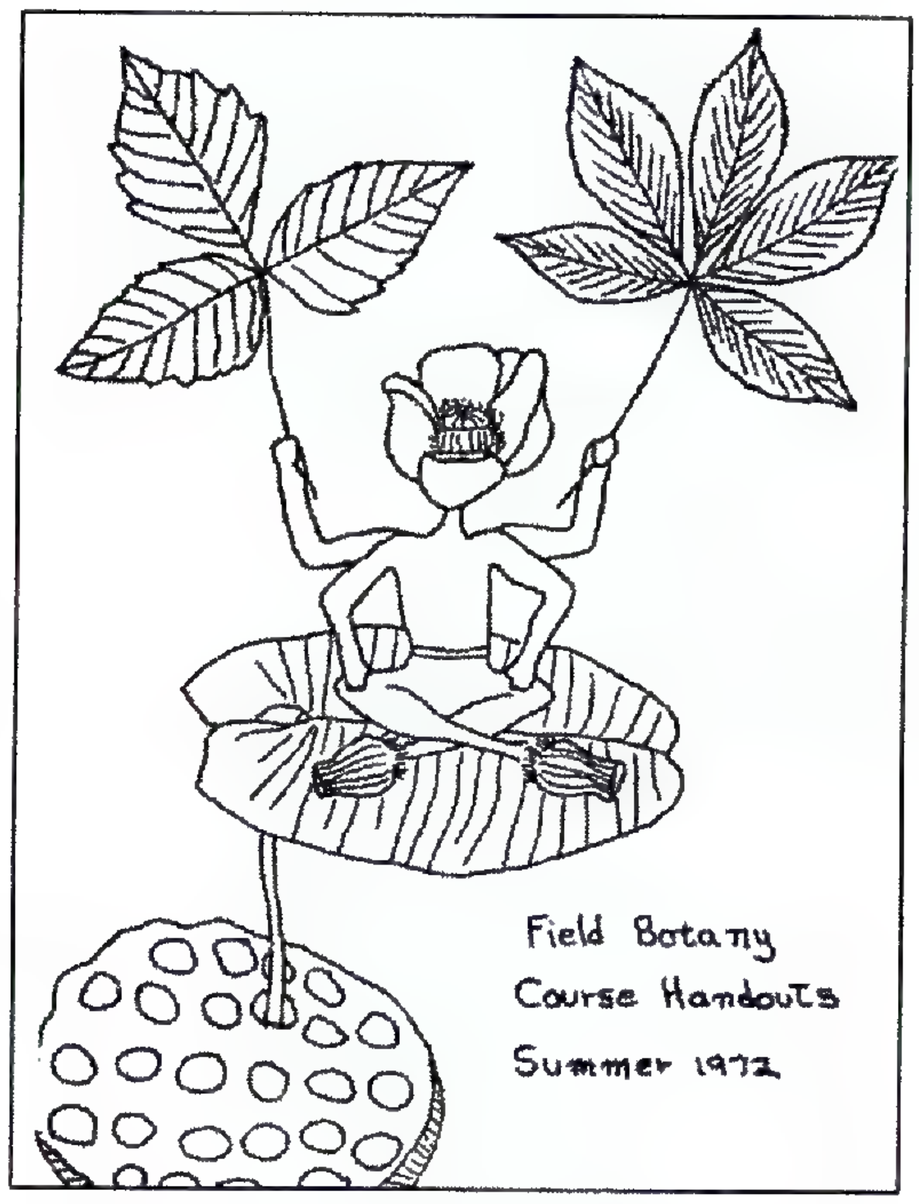
That lovely young Mädchen Miss Schiller
With plant names I really did fill 'er.
But a turtle so cool
She found in a pool
Was really, I think, what did thrill 'er.

There goes that bold man Rick McGill
Out for a botanical kill.
He works day and night
With all of his might
And does get his plant press quite fill.

And last, but not least, Fearless Leader.
Whose disciples learned oak, elm, and cedar.
How oft, on The Rock
He did gather his flock
And exhort them there, much like old Peter.

At the conclusion of the poem, John wrote, " . . . presented with thanks and appreciation to my Stone Lab Students. Long may they flower!"

The verse pertaining to Rick McGill is noteworthy as he was working with me for his master's degree making a comparison of the vascular plant flora of the two lakes in northern Champaign County, Ohio (completed 1973; not published).



Cover page of John W. Thieret's Field Botany, Course Handouts, Summer 1972.

John W. Thieret, Tom Duncan, and the "Flora of the Erie Islands" (1972–2005)

Tom Duncan, an undergraduate majoring in education and working as a teaching assistant in chemistry at the The Ohio State University, introduced himself to me during his sophomore year in the early spring of 1968. Later that spring he accompanied me on field trips learning the local flora, and in the spring of 1969 he began working as an assistant under my direction in the OSU Herbarium. That summer I invited Tom to serve as my research assistant at the F.T. Stone Laboratory. He continued to serve part-time as my research assistant on the *Flora of the Erie Islands* until he graduated at the end of the fall quarter 1970. Tom continued working on the Flora manuscript from 1971 through 1973 while he was a graduate student at the University of Mighican. He earned his Ph. D. in Botany there in 1976 and was employed as an assistant professor botany beginning 1 July 1976 at the University of California, Berkeley. He was granted tenure there in 1982, was the Director of the Herbarium 1982–1991, then became Director of the Museum Informatics Project until his retirement in 2002 as an associate professor emeritus at age 54.

I first met John W. Thieret in July 1972 at the Franz Theodore Stone Laboratory on Gibraltar Island in Lake Erie. John was at Stone Laboratory for the summer to teach Field Botany. I was visiting Stone Laboratory for a few days to discuss with Ronald L. Stuckey progress on the preparation of our manuscript titled *The Flora of the Erie Islands: Its Origin, History, and Change.*

Stuckey initiated a project on the flora of the Erie Islands in the mid-60s. In 1969, I undertook a project as his research assistant on the changes in the flora of the seven small islands in western Lake Erie (*The Michigan Botanist* 9:175–200. 1970), and was invited to collaborate on the more inclusive project in 1970.

By 1972 we were in the initial stages of preparing together a manuscript describing the results of our research.

John Thieret was spending his second summer as an instructor at Stone Laboratory. He had become intensely focused on the flora of the islands and was interested in discussing with me the progress to date on my collaboration with Stuckey in this regard. One area we discussed was the lack of information in previous floras about cultivated plants on the islands.

Cultivated species are of interest because they are an important source for the adventive and naturalized flora of the islands, are a conspicuous aspect of the flora, and are an important feature of the flora for the residents of the islands. John and I concluded that we would undertake a survey of gardens on South Bass Island and compile a list of the cultivated flora for inclusion in the manuscript Stuckey and I were preparing on the total flora.

We spent a day wandering the roads of South Bass Island stopping at houses and asking local residents if we could examine and record the names of the plants in their gardens. With a copy of Liberty Hyde Bailey's *Manual of Cultivated Plants* (1949), in hand, we were able to prepare a preliminary list of plants. Ultimately this list included 258 taxa.

John often stated that our field trip on South Bass Island that day was one of his favorite memories of his time at Lake Erie. After our initial meeting in 1972 we continued to correspond and talk on the telephone about the progress of the flora manuscript. In 1982 John brought the nomenclature of our list of cultivated plants up to date using *Hortus Third* (1976), the nomenclatural reference for cultivated plants at that time. In his letter of 3 February 1982 he concluded by saying, "best wishes from John. I wish we could wander over South Bass Island again. Fun, fun, fun."

Whenever I think of these events, I am always reminded of John's charming personality, his appreciation of natural history, and his joy in studying plants. His interest in the flora of the Erie Islands continued for over 30 years until the end of his life.

Stuckey and I completed our manuscript in 1976 and submitted it to the Ohio Biological Survey for publication. The Survey accepted the manuscript for publication and planned for publication in 1979. John volunteered to serve as editor for the Survey and worked extensively on the manuscript. Unfortunately, the Ohio Biological Survey could not publish the manuscript at that time, partially because of the lack of funds, and Stuckey's involvement with other projects for the Survey. For the next 20 years the manuscript and three edited copies resided in Stuckey's office with an additional copy in the Franz Theodore Stone Laboratory library.

During this period, John continued his interest and frequently asked both Stuckey and me if we would complete the manuscript and find a way to render it in a form for wide distribution. During a visit to The Ohio State University in

1999, Stuckey and I discussed what might be done to resurrect the manuscript, complete it with all editorial suggestions incorporated, and either publish it or distribute it electronically.

John was enthusiastic about this turn of events and offered his services to help us in any way he could. Progress in this direction was made but no definite arrangements about a means of distribution had been made by the time of John's death. We are investigating the possibility of distributing it through the digital Knowledge Bank at The Ohio State University. Ronald L. Stuckey and I are determined to complete this task to honor John's long-standing interest in the Erie Islands, and we plan to dedicate the completed flora to him.

Thieret and Stuckey's Promotion (1972)

Later in the year 1972, John made an important contribution to my career. He wrote a letter, dated 19 October, supporting my promotion to full professor in The Ohio State University. Addressed to Botany Department Chairman John A. Schmitt, it was short and to the point, quoted here in its entirety:

> It seems to me that Dr. Stuckey has shown himself to be a competent and indefatigable researcher. His frequent publications attest to his capabilities not only as an "original researcher" but as a skilled synthesizer of the work of others.
>
> [P.S.] John: This is a trite, trivial, and, for me, traumatic letter. I simply cannot rise to greater heights. Even though the subject is worthy of those greater heights. J[ohn]

Again, Thieret and Stone Laboratory (1974, 1977, 1981, 1983, 1986)

After 18 years as Director of the Stone Laboratory, Putnam retired following the summer session of 1973, and College Dean Richard H. Bohning appointed Dr. Charles E. Herdendorf to succeed him. Now Professor and Director Emeritus, Herdendorf, on 23 March 2006, provided his remembrances of John Thieret, briefly reviewing the succeeding summers John taught Field Botany at the Laboratory—a total of seven summers over a 15 year period.

I first met Dr. John W. Thieret, in 1971 at the Stone Laboratory where he was teaching a summer course in Field Botany, and I was beginning to organize the newly founded Center for Lake Erie Area Research (CLEAR) at the Laboratory. The next year we both served on the summer faculty of Stone Laboratory, Dr. Thieret again teaching Field Botany, while I taught Physical Limnology. Financial constraints in 1973 caused the cancellation of classes at the Laboratory, but by 1974 I had assumed the duties of Laboratory Director, and Dr. Thieret was invited again to teach field botany. In 1974, Dr. Thieret and his class also participated in a CLEAR research project titled *Ecological Analysis Related to the Proposed Seawall Improvement and Ground Rehabilitation Project at Perry's Victory Monument, Put-in-Bay, Ohio*. Dr. Thieret returned to Stone Laboratory to teach Field Botany in 1977, 1981, 1983, and 1986. On June 30, 1983, he also participated in the Stone Laboratory Guest Lecture Series by presenting a seminar titled *The Muskeg and I: Exploring for Plants in Canada's Northwest Territories.*

Other than his account of the boreal plants along the new Yellowknife Highway, one of his most memorable descriptions was that of the voracious infestation of black flies encountered around Great Slave Lake. John Thieret is fondly remembered for his dry sense of humor and fascinating stories of field experiences. Some of his students may have found him to be excessively demanding, but all received a quality introduction to the study of Field Botany.

I was not present at the Stone Laboratory in the summer of 1977, but my masters graduate student John R. Wehrmeister attended and took the Field Botany course from Theiret. Student Wehrmeister was researching the ecological life cycle of the pondweed *Potamogton crispus* in North America (completed 1978; published in part *The Michigan Botanist* 31:3–16. 1992). In 1981, Mr. Wehrmeister earned an M.D. degree from the Medical College of Ohio in Toledo, and he has had a successful career as a physician in the practice of internal medicine in the Maumee-Toledo, Ohio, area. In reply to my request, he wrote the following commentary:

I am pleased to offer thoughts about Dr. Theiret. His personality and teaching style has had a lasting impact on me. I had heard Dr. Thieret give a lecture on the botany of the Northwest Territories, Canada, when I was a student at the University of Michigan Biological Station at Pellston. Dr. Theiret was a visiting faculty member there in 1975, but I did not get to know him that summer. Later in 1977, while studying at The Ohio State University, I took his Field Botany course at the Stone Laboratory. Following the course, in late August and early September, my friend Ed Toth, and I accompanied Dr. Thieret on a plant collecting trip to Louisiana, and upon returning, visited with him at his home in Highland Heights, Kentucky.

Thoughts of him are full of fond memories. He was a delightful man, a favorite but serious teacher, and a scholar with a great sense of humor. Memory of his facial expression includes what seemed to be a permanent grin. "Dr. Thieret anecdotes" were the order of the day among his students. Good-natured though he was, in contrast he was strongly serious in the classroom. With some embarrassment I remember being admonished by him for the poor effort I showed in mounting herbarium specimens for an early class project. At my request Dr. Theiret wrote a letter of recommendation for some job or school position to which I'd applied. He thereupon sent me a purported carbon copy of the letter which, perhaps needless to say, was far from complementary. Luckily this was one of his pranks. The real letter contained the usual laudatory comments.

A few additional observations of Theiret's summers at the Stone Laboratory are noteworthy. By 1981, he had modified the "Course Handouts" book. On the cover that summer was a branch showing the leaves of the hackberry tree, one of the most common trees that grew on the shallow limestone and dolomite bedrock. On page 4 was the quotation, "The beginning of wisdom is to call things by their right names.—Oriental proverb."

In his course the students only were required to learn the scientific names of the plants. I did not agree with him; rather I taught students to learn both the



John W. Thieret's Field Botany Class at the F.T. Stone Laboratory, Summer 1981. Taken in the northwest limestone quarry on Kelley's Island, Erie County, Ohio, by Ronald L. Stuckey, July 1981. Left to right: Tonya Shank, John W. Thieret, George F. Buddell, II, assistant; five men students, in alphabetical order not matched to individual in the photograph: Ron Baker, Doug Brewer, John George, Mark Harrell, and Dan Wojta.

scientific and common names, which would allow them to communicate with persons of many different educational backgrounds and professions. His editorial style gave me concern also, but I never discussed it with him. He continually overused the dash, which therefore changed my writing style. I also became annoyed when he was editing the "Flora of the Islands." I often listed several plants in sequence. He would change the sequence by aligning them in alphabetical order. My choice of sequence usually was to list them from the most common or typical to the less common in a particular habitat. My alignment was ecological related as to where the plants grew. Plants do not grow in places alphabetically, but he apparently was not aware that my order of the plants also had a meaning.

John liked to talk as he himself has written. During two other summers he gave a presentation in the Guest Lecture Series, on 19 July 1977 and 30 June 1983. Both times, his title was "The Muskeg and I," which was just as delightful as it was the first time with the more formal title, when he gave it in the summer of 1971.

Andrea Wilson, now Mrs. Matthew Schlageter in the Southeastern Development Office of The Ohio State University, Bonita Springs, Florida, came in

the summer of 1982 as Director Herdendorf's Laboratory Secretary and Administrative Assistant. She knew John Thieret from the 1983 and 1986 summers at the Laboratory. Her statement sent to me 24 March 2006 concisely summarizes John's presence there.

I vividly recall Dr. John Thieret as a very kind and thoughtful man. He always had an encouraging word and a smile for everyone. He was devoted to his teaching and research and was well respected by all whose lives he touched. His memory will continue to live not only in his publications, but also in the knowledge he shared with his students.

Thieret, Book Reviews, and Stuckey (1973–1979)

During the five year period of 1973–1979, Thieret sent me books to review for the journal *Economic Botany*. For 25 years, 1959–1984, John voluntarily served as book editor for *Economic Botany*. John's strive for perfection gave the journal "a reputation as having one of the most comprehensive and best edited book review sections of any professional journal. When at times the acid pen of a reviewer might be too harsh on an author, John would always suggest a critical but more even-handed approach." (W. Hardy Eshbaugh, *Economic Botany* 38(4): 498. 1984).

John usually sent me local flora or plant taxonomy books to review. Initially he sent me two books with a letter dated 24 September 1973. The book titles were *A Flora of the White Mountains, California and Nevada* by Robert M. Lloyd and Richard S. Mitchell (1973) and *The Genus Lesquerella* (Cruciferae) *in North America* by Reed C. Rollins and Elizabeth A. Shaw (1973). Thieret's suggestions were:

> Probably the best thing to do so far as the flora is concerned is simply to produce a "notice" of the work. A full-blown "review" is not necessary. If you can get the notice and the review to me in about 3 months or less, I'd be ecstatic. Allot about 150–200 words for the flora, about 300 for the mustard opus. Of course, if you feel you really need more—or do not need so many—the final decision is yours

I wrote 10 book reviews for *Economic Botany*. They and all of my other book reviews are available in my archives at the Hunt Institute for Botanical Documentation, Pittsburgh, Pennsylvania. John wrote his own review about his 25 years as Book Review editor. He considered it as "one singularly devoid of excitement." One colleague, with perhaps a touch of jocularity, called him the "dean among U.S. book review editors" (*Economic Botany* 40:24–26. 1986).

Thieret, Aquatic Plants, and Stuckey (1982–1983)

I had forgotten that during the summer of 1983 when John was teaching at the Stone Laboratory, he asked me to review the book manuscript he was completing for the late Ernest O. Beal on the "Aquatic and Wetland Plants of Kentucky." On 26 August 1983 John wrote:

> I hope you remember that you have gone over both major sections of the book, i.e., the dicots (sum-

mer 1982) and the monocots (summer 1983). The comments you made on the monocots were (as were those on the dicots) gratefully received. Most of them have been incorporated into the book, improving same! I appreciate your willingness to read our prose. I'm working hard on the book, hoping to meet a deadline of 1 November 1983 for getting he book to the publisher. Best wishes.

I further helped John with the book by writing on 2 September 1983 a supporting letter for its publication to Richard Hannan of the Kentucky Nature Preserves Commission:

"Dr. John Thieret has asked me to write in behalf of his manuscript coauthored with the late Dr. Beal on the aquatic and wetland plants of Kentucky. This manuscript is very carefully prepared in all aspects. Dr. Thieret has gone to great lengths to check the accuracy of identifications of specimens seen, the reliability of literature records and citations, and the conciseness and correct usage of technical terminology. His work in this regard is very well done, and adds great credibility to a work of this type.

Very few states have books on their aquatic plants, and this book will be a welcome addition to those books on aquatic plants. Perhaps, more important, however, is that this book will be extremely valuable in a state which has no "modern" general flora. Consequently, this book will be a valuable contribution to that "modern" general flora that needs to be generated. Those needing floristic information will at least be able to get current information on aquatic and wetland species. I trust that you find this contribution worthy of publication, as I anxiously look forward to seeing it in print.

In the book's acknowledgements by Thieret, my name, along with many others, appears among those who "gave aid during the preparation of this book."

Thieret and Stuckey Since Summers at Stone Laboratory (1996–2005)

Since the summer days of the 1970s and 1980s at the Stone Laboratory, most of my contacts with John Thieret have been by telephone, except the following interactions which are noteworthy. When John became editor of the *Transactions of the Kentucky Academy of Science*, I thought he could help me with publishing some of my writings that were nearly completed on the controversial North American botanist Constantine Samuel Rafinesque (1783–1840). I had published several papers on Rafinesque's botanical studies earlier in my career. Since Rafinesque had held the position of Professor of Botany and Natural History at Transylvania University in Lexington, Kentucky, from 1819–1826, my contributions were appropriate for the Kentucky Academy's publication. With the assistance of my botanical friend, James S. Pringle of the Royal Botanical Gardens in Hamilton, Ontario, Canada, we published, with John's editorial assistance, "Common names of vascular plants reported by C.S. Rafinesque in an 1819 descriptive outline of four vegetation regions of Kentucky" (*Trans. Kentucky Acad. Sci.* 58:9–19. 1997). At the Bicentennial Celebration of Rafinesque's 200th birthday held on the campus of Transylvania University, 21–22 October

1983, I spoke on "Opinions of Rafinesque expressed by his American botanical contemporaries" (*Bartonia* 52:26–41. 1986; reprinted with some changes in Charles Boewe (*Profiles of Rafinesque*. Chapter 10. 2003). Following that event, and as a contribution toward my studies of the pioneer botanists of the Ohio River Valley, I wrote an extensive manuscript on "Rafinesque's Botanical Pursuits in the Ohio Valley (1818–1826)." With John Theiret's editorial skills, 14 years later this manuscript was completed and published by the Kentucky Academy of Science in its newly titled *Journal of the Kentucky Academy of Science* (59(2):111–157. 1998).

John appreciated and was very supportive of my scholarship on the history of nineteenth century North American plant taxonomists and their work. He asked me for a short project he could contribute about Rafinesque in Kentucky. I suggested he return to the localities in the state where Rafinesque obtained plants that he named as new to science. He was delighted with the idea, and by automobile during a week in July 1999, John and his friend, David M. Brandenburg of the Dawes Arboretum, Newark, Ohio, retraced a botanical excursion that Rafinesque took during 1823 in central and south-central Kentucky. Rafinesque's itinerary was outlined in his autobiography, *Life of Travels* (1836), which took him two months to complete on foot. A short description of the Thieret-Brandenburg trip appeared in the *Flora of North America Newsletter* (13:(3–4). 1999. July–December). David and John wrote the full story of the trip under the title, "Rafinesque and Us" (*Lloydiana* 6(1):4–9. 2001).

During retirement, my friend George W. Paulson, emeritus professor of medicine in the Medical Center of The Ohio State University, has been writing about early medical practices of the pioneer physicians in the central Ohio area. Among these physicians was Samuel Thomson (1769–1843) who discovered that chemical extracts from the leaves and seeds of the plant, *Lobelia inflata*, had medical properties that potentially would cure headaches, tinnitus, syphilis, and especially as an expectorant to loosen bronchial congestion. Paulson wanted to write a paper on Thomson, and asked me to help with it since I would know about the *Lobelia* plant. Most of the paper was written by George, and I edited it, but George could not locate a journal for its publication, so he asked for my help. I thought *Lloydiana*, a quarterly periodical of articles for the popular audience published by the Lloyd Library in Cincinnati, would be an ideal place for its publication. I talked to John Thieret on the telephone and asked him for his review of the article and editorial assistance. John, a member of the Board of Trustees of the Lloyd Library, helped with revision and editing of the article, which appeared in *Lloydiana* (8(3):2–6. 2004. Summer). Lloyd Library Director and editor of the periodical noted in her column, "From the Director," that the Thomson-*Lobelia* paper was indeed an "interesting article." John Thieret so ably helped make it possible to be printed in the Lloyd Library newsletter.

Nearly every time John and I had a telephone conversation since our teach-

ing days at the Stone Laboratory, he always asked about progress on the *Flora of the Erie Islands*, and he wanted me to finish it. I always had to think of some excuse, mostly that I was involved in other more worthwhile projects. Some relief came for me when Tom Duncan returned to my office in 1999, and he agreed to take all of the various components related to the project with him to Berkeley, California. There he has worked on the *Flora* to reflect our knowledge of it, as it was in the 1970s. Tom wrote of his role in this effort in this paper.

For 30 years, from about 1971 to 2001, I was at work preparing another kind of book about South Bass and Gibraltar Islands. Titled "Lost Stories," the book includes Theresa Thorndale's "Island Jottings" about selected places on these islands of the 1890s that she published in the *Sandusky Register*. My contribution describes these same places on the islands a century later during the 1990s. This book won the 2003 Florence Roberts Head Book Award given by the Ohioana Library Association of Columbus, Ohio. In his last known note to me, John Thieret wrote, "Many thanks for the info[rmation] on your award for the Put-in-Bay book. I'm so glad that you did such a book. You certainly deserve the award." I sometimes think that for John, it may have been a consolation prize for the *Flora of the Erie Islands*.

John Thieret was a most unusual botanist. I know of no one else like him. His dedication, his kindness, his sense of humor, his field knowledge of plants, and the numerous and varied ways he helped me through my career has been a most worthwhile and enjoyable adventure.

ACKNOWLEDGMENTS AND SOURCES OF INFORMATION

I am especially grateful and thankful to Kathy Royer for preparing the final typewritten manuscript of this paper for publication in *Sida*. I also extend grateful thanks to David I. Moore, Tom Duncan, Charles E. Herdendorf, John R. Wehrmeister, and Andrea (Wilson) Schlageter for their written contributions to this paper. Notes made during telephone conversations with the above individuals and the letters referenced in this paper are filed under the title of this publication in the Archives of Ronald L. Stuckey and in the Archives of the Hunt Institute for Botanical Documentation, Pittsburgh, Pennsylvania. As an added note, former Stone Laboratory Director Loren S. Putnam died during the writing of this paper, 19 April 2006, at age 92.5 years.

JOHN W. THIERET, COLLEAGUE AND EDITOR FRIEND (1969–2005)

William F. Mahler

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John Thieret's reputation as a dedicated botanist and unique individual preceded our actual meeting, which occurred sometime in the late sixties. Over the years we drifted apart, but the impact John made on my professional career and my success with *Sida, Contributions to Botany* remains strong. Although he spent the night at our house only a couple of times when he visited the SMU herbarium, the field trips we took in my 1969 red Ford pickup were the highlights of our botanical relationship.

Our biggest collecting trip was to Guadalajara, Mexico in April of 1970. We traveled by way of the Chihuahuan Desert and then returned through the Sonoran Desert. The pickup was the perfect mode of transportation for a long-range collecting trip because of the saddle tanks and the camper shell. We could travel six hundred miles between fill-ups and could sleep in the back if we couldn't find lodging. Also, there was plenty of room for all our collecting supplies.

The decision to take this particular trip was made on a lark. We'd heard of others doing this and so we thought we'd do the same. As it turned out, we actually did find quite a few noteworthy specimens. When Rupert Barneby found out where we were going, he suggested we visit some locations for the legumes that he had collected some years back. He needed some flowering specimens. We were successful in finding some specimens north of Zacatecas, which he cited in his monograph on *Dalea*.

The trip was far from boring. North of Guadalajara, John injured his ankle while trying to get a specimen from the branch of a tree. He knew he had sprained his ankle, but he was afraid he might have broken it, too. An x-ray in a hospital in Guadalajara showed no apparent broken bones, but judging by the amount of pain and the routine swelling by the end of the day, John felt that it was more than just a sprain. However, with my expertise in speaking Spanish, I managed to find ice at motels to treat the swelling. We were able to continue with our collecting trip.

John was always the teacher. To pass the time when driving, we would grill each other on botanical glossary terms and other aspects of botany. I had never taken an economic botany course, but I survived the equivalent of one after experiencing the tropics with him. He was the opposite of me, since I eat to live

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John Thieret, Chihuahuan Desert, Mexico, April 1970.

and he lived to eat. In the restaurants, meals were scrutinized very diligently and I was often quizzed on the content. He ate and sampled many kinds of fruits from the markets, many of which I had never heard of. In the field, he was always tasting and smelling the fruits, leaves, etc. and discussing the results after spitting out the remains. His knowledge of tropical fruits was uncanny.

We followed the coastline on our way home. As we neared the border, we drove past a bakery in a small town. John's acute sense of smell overcame him and I had to turn around so he could stock up on some bread before we left Mexico. My common sense told me to refrain since we had come that far with no digestive problems. As it turned out, he did get a light case of diarrhea, but I did not pursue the issue.

At Mazatlán, we bought more newspapers (by the kilos) for our collections at the local newspaper office, and we spent our last night in Mexico south of Nogales, Arizona. U.S. Customs wanted time to go through our specimens looking for rusts for one of their projects. We went to dinner (lunch) and when we returned, customs had just finished. We headed back to Texas with our many collections and John's foot still in pain.

Once we got on the road, John got anxious to get home and check out his injury. We drove all night and stopped in Abilene, Texas for gas the next morning. At Love Field in Dallas, I let him out at the airport where he caught a plane



John Thieret, Chihuahuan Desert, Mexico, April 1970.

and I went on home. I arrived home about five o'clock in the afternoon after being up and at the wheel for thirty-six hours. John told me later that they had found a hairline crack in one of his ankle bones in addition to the sprain.

Although John was not one for attending meetings, he agreed to accompany me in the red Ford pickup to the Southwestern Association of Naturalists meeting in Tucson, Arizona. During registration, he headed over to a young man and shook hands. The fellow seemed confused and asked John if they had met before. John informed him that they had been officemates for ten years back in Chicago. John's appearance was much different because he had shaved his beard that he had always had. Everyone had a good laugh about it, especially John.

The field trips were productive and entertaining, but John's most valuable contribution to my career was his involvement in *Sida*. Lloyd Shinners had told me that I needed to meet John when I first arrived at SMU, and he was right. When I inherited *Sida*, he, along with others, encouraged me to continue its publication, as opposed to others who felt I should drop the journal. With the help of Mrs. Helen Koresh, a sister of Lloyd's, I was able to clear the financial obligations Lloyd had encumbered with the authors of unpublished manuscripts. I sent John some articles for him to review that I had written about Lloyd. John really "cleaned them up" and returned them with more red ink than black.

This was the beginning of his "internship" and status as Associate Editor of *Sida* that he held until his death.

I have always considered myself lucky to have associated with many individuals whose knowledge and insight enriched my professional knowledge and furthered my career goals. John was one of those individuals. The wide range of things I learned from John—both professionally and as a friend—will always figure significantly in my life.

JOHN W. THIERET, ASSOCIATE EDITOR OF SIDA (1972–2005)

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John W. Thieret was an extraordinary and innovative teacher who shared his knowledge freely. Without doubt he was an influential botanist and one of the most distinguished editors of the 20th century at least in North America. "Big John," as I sometimes called him, was my steady and faithful cheerleader, *Sida* supporter, and crusader *extraordinaire*. He was always there whenever I needed advice or help with *Sida* or for that matter anything. Notwithstanding John's many obligations, he called me after receiving each and every issue of *Sida*. And the voice I heard each time was inspirational, always filled with praise for the good but soft and tender on the good that could be better. John's source of inspiration was perhaps from the many years of editorial experience with *Economic Botany*, *Flora of North America*, and the *Journal of the Kentucky Academy of Science*. John knew first hand the amount of work involved and maybe sensed there was always room for a little more praise than was given [to editors everywhere]. "Keep up the fine work good ole fellow! How are you doing? How are you holding up? Let's go on a field trip! Now is there anything you would like for me to do? Edit a manuscript? Review a book and write a review? Whatever it is just send it my way and I'll promptly return it to you." John Thieret was forever supportive and never failed to do what he said he would do. He was always thinking of how he could help the other person and I always felt like I was that other person. John so loved *Sida* that he gave nearly 40 years of his life. To John be the glory—great things he has done for *Sida, Contributions to Botany*! This is my tribute to him.

Highlights of John Thieret's contributions to Sida

Ralph Thompson's (2006) excellent tribute provides a detailed account of the great service John Thieret rendered to botany and academia, his chosen fields. My tribute will recount his great and lasting contributions to a journal he cared so much about, *Sida, Contributions to Botany*. John's love and early relationship with *Sida* was tied closely to that of his colleague and friend Lloyd H. Shinners at Southern Methodist University. Therefore, I pick up John's trail of communication with Shinners even before Shinners started *Sida* in 1962.

1961—According to Ginsburg (2002), "Thieret was on staff of the Chicago Natural History Museum when he wrote to Shinners in 1961 to inquire about academic

positions for botanists. Shinners was very helpful, and when Thieret moved to the University of Southwestern Louisiana [Lafayette] the two became friends and close collaborators." Thieret wrote,

"I really think that a private line ought to be established between your herbarium and ours..."

Music was another shared enthusiasm.

1962—Lloyd H. Shinners alone wrote, edited, and published the first two issues of *Sida* which were distributed on November 23rd. He said that he would have to publish his own journal because his own articles would never be published otherwise. So it was quite a tribute when he published others' papers.

1963—With the publication of the third issue of *Sida* on December 13, John Thieret became the fourth author aside from Shinners to have a paper published in the journal, behind W. Phillip Osborne, Walter H. Lewis, and Arthur Cronquist. John's 54 page Yellowknife Highway paper followed Arthur Cronquist's paper, *The taxonomic significance of evolutionary parallelism.*

Botanical survey along the Yellowknife Highway, Northwest Territories, Canada. I: catalogue of the flora. Sida 1(3):117–170.

1964—Five of John's manuscripts were submitted and published in 1964. The first issue contained the second part of John's botanical survey along the Yellowknife Highway. In addition, *Sida* 1, no. 4 contained another significant and memorable event for John Thieret. A new flowering plant species was named in his honor for the first time ever. Lloyd Shinners (1964) named *Scutellaria thieretii* (Labiatae) for John. Lloyd wrote, "The Louisiana plant is considered to be one more in a group of very closely related species, and in honor of an energetic and productive collector it is named....I am indebted to Dr. Thieret for supplying the two SMU collections, and for the loan of mounted specimens from the University of Southwestern Louisiana." And so the relationship between John and Lloyd strengthens.

Botanical survey along the Yellowknife Highway, Northwest Territories, Canada. II: vegetation. Sida 1(4):187–239.

Shinners began work on *Sida* 1(5), but it was a struggle to get the manuscripts ready for the printer (Ginsburg 2002). Thieret apparently offered help with issue no. 5, but I could find no correspondence indicating whether or not Shinners ever took John up on his offer. Maybe John helped by submitting well-written and superbly edited manuscripts for Lloyd to publish.

Fatoua villosa (Moraceae) in Louisiana: new to North America. Sida 1(4):248.

Lysimachia japonica (Primulaceae) and *Clinopodium gracile* (Labiatae) in Louisiana: new to the United States. Sida 1(4):249–250.

More additions to the Louisiana flora. Sida 1(5):294–295.

Eriogonum annuum (Polygonaceae): biennial in Nebraska. Sida 1(6):382.

1965—There was a break in the action for John as far as submitting papers to *Sida*. John did not have a single paper in either of the two *Sida* issues published in 1965. Regardless, John apparently stayed in close contact with Lloyd.

1966—The next documented account of correspondence between John and Lloyd took place on January 26.

"I am sending, for possible publication in SIDA, a manuscript entitled "Seeds of Some United States Phytolaccaceae and Aizoaceae." The article was published on September 27.

Seeds of some United States Phytolaccaceae and Aizoaceae. Sida 2:352–360.

Sometime in 1966, Shinners had his first "all out" case of insulin shock and after hearing about that, Thieret wrote, "I was appalled to hear your account of the insulin shock." I suspect John once again offered Lloyd help with *Sida* but apparently no letter with such words are in Shinners' archives. Shinners recovered from the insulin attack and published a fourth issue of *Sida* in 1966; volume 2, number 6 was published on December 30.

1967—According to Ginsburg (2002) Shinners was probably exhausted after publishing four issues of *Sida* in 1966 and even more exhausted after his second NSF grant ended in May 1967. Thieret apparently kept in close enough contact to know the details. According to Ginsburg (2002), "He [Thieret] was willing to come to Dallas for a weekend to help in getting an issue together, or he would read and edit anything that Shinners might send." In a letter to Shinners, Thieret once again offered assistance with *Sida*.

"*Sida* is a most worthy cause. To help out is a privilege..."

John not only continued to correspond with Lloyd, but he also submitted manuscripts to *Sida* and Lloyd published four of John's papers in 1967.

Supraspecific classification in the Scrophulariaceae: a review. Sida 3(2):87–106.
Thirty additions to the Louisiana flora. Sida 3(3):123–127.
Cyperus subgenus *Kyllinga* (Cyperaceae) in the continental United States. Sida 3(3):128–136. [with A.J. Delahouhoussaye]
Neogaerrhinum kelloggii (Greene) Thieret, comb. nov. (Scrophulariaceae). Sida 3(3):187.

1968—John Thieret wrote Lloyd on April 18, 1968.

"With regard to *Maurandella*, it gives me great pleasure to enclose a copy of Rothmaler's paper on the Antirrhineae. To think that the Thieret library could contribute something to the Shinners library!!!!!

Glad to hear, also, that SIDA is such a well-going concern. Once again I make an offer to come to Dallas for a weekend if I can be of help—real help—in getting together an issue. Also, I'll be glad to read and edit anything you send over. Even that Czech paper—which you specifically said not to edit, you will recall."

Two issues of *Sida* were published in 1968 but John did not have any papers in either issue.

1969—Shinners published two issues of *Sida* in 1969: 3(5) and 3(6), August and

November respectively. In between those two issues John sent Lloyd a letter dated September 9, 1969:

"I was surprised to get the *Bigelowia* [Anderson] opus. Have you decided to establish an editorial board to "protect" your contributions against non promotion? (Ha!)

After hearing about another round of Shinners' health problems, Thieret again offered to help proof read *Sida*.

"You are willing I recall to have me take care of the index for vol. 4 of *Sida*. Right?"

Meanwhile John submitted four manuscripts for publication. Undoubtedly they were submitted in excellent shape and Lloyd probably had to do very little work on these papers to get them ready for publication.

Sagittaria guayanensis (Alismataceae) in Louisiana: new to the United States. Sida 3(6):445.

Rumex obovatus and *Rumex paraguayensis* (Polygonaceae) in Louisiana: new to North America. Sida 3(6):445 -446.

Baptisia lactea (Rafinesque) Thieret, comb. nov. (Leguminosae). Sida 3(6):446.

Trifolium vesiculosum (Leguminosae) in Mississippi and Louisiana: new to North America. Sida 3(6):446–447.

1969–1970—William F. Mahler was appointed three-quarters time assistant professor in the Biology Department at SMU and one-quarter time with the herbarium. Shinners' Herbarium Report involved mostly Mahler's activities; *Sida* activities were still under the control of Shinners. Once again John offered Lloyd help in another letter probably dated sometime in April or May 1970 (see also Mahler's tribute).

"Went on a collecting foray this past weekend—the first extensive one since I got back from Mexico. The ankle still gives trouble... Indeed, by the time the collecting trip was over, I was limping something awful (!).

You were willing, I recall, to have me take care of the index for volume 4 of SIDA. Right???... If you are still, I shall get onto the task, a bit at a time. Shaw's paper alone is a challenge."

1971—Lloyd Shinners published *Sida* 4(2) on January 15, 1971 and one month later Shinners passed away on February 16, 1971. William F. Mahler inherited *Sida* from Lloyd's sister Helen Koresh and he immediately became editor and publisher. February 17, 1971, the very day after Lloyd's death, John Thieret composed and mailed a letter to Mahler at SMU offering personal assistance and moral support.

"Just a note to reaffirm my offer to do what I can do to help keep SIDA a going thing. The journal should certainly not be allowed to die but should be kept viable as, perhaps, a memorial to its founder.

As for specific things I could do, I certainly would be glad to help on editing. I would be willing to come over there every once in a while to work closely with you or with anyone else interested. Editing, reading proof, indexing—all would suit me fine. Speaking of indexing, Lloyd already gave me the go-ahead on doing the index for volume 4.

Certainly you are thinking of an article on Lloyd, in SIDA, with possibly a list of his publications. I'd be glad to help here, especially on the bibliographic work involved.

There! My offers have been made. It is now up to you to see that they are taken up!

Would it possibly help if [William] Reese and I were to send some sort of letter to the SMU president to urge him to do all he can to keep SIDA going?"

John Thieret was concerned about the future of *Sida*. Here is his letter to SMU urging Southern Methodist University's President Dr. Willis M. Tate and the Dean of Graduate School, Dr. C.C. Albritton, Jr., to continue the publication of *Sida*.

"The name of the president I got from the 1969–70 edition of the WORLD OF LEARNING. I assume that Tate is still the man. The Albritton part is for certain OK.

I am going to say that botany has lost a shining light (or something like that) and that I strongly urge SMU to do all it can to continue the publication of SIDA, a journal that is an excellent one that has filled a need. Etc. Etc. Etc. Signed John T.

Even with all the encouragement from a number of Lloyd's colleagues, Southern Methodist University never committed to preserving the journal or the collections that really made a name for the university in the botanical sciences. Other scientific journals were also born there but either died there or moved on to more supportive organizations. The dedication and hard work that Lloyd Shinners devoted in championing the cause of botany at SMU was kept alive through colleagues and the Botanical Research Institute of Texas (BRIT). William Mahler committed 21 years of personal time and money in keeping *Sida, Contributions to Botany* successful. In 1987, Mahler along with colleagues Lipscomb and Andrea McFadden were instrumental in the establishment of the free-standing research institution BRIT. The core of the BRIT collections is the Lloyd H. Shinners Collection in Systematic Botany, originally at Southern Methodist University. Since *Sida* was privately published by Mahler it too joined BRIT. Mahler officially transferred ownership of *Sida* to BRIT in 1993.

Mahler (1971) published *Sida* 4(3) with a tribute to Lloyd and John had one paper in the same issue:

Physalis lagascae (Solanaceae) in Louisiana: new to the conterminous United States. Sida 4:277.

John's offer of help was at last accepted. Mahler officially asked him to serve as associate editor of *Sida* in late 1971 or early 1972. One of the first papers John edited as associate editor was a large manuscript on the genus *Rorippa* sent to Dr. Shinners (early 1970) by Dr. Ronald L. Stuckey, associate professor of botany at Ohio State University. Dr. Stuckey expressed a desire to help with *Sida* in a letter dated February 24, 1971 to Dr. Mahler and Dr. Thieret.

It has come to my attention that Professor Lloyd Shinners has passed away. I talked with John Thieret by phone recently and he suggested that I write to you [Mahler]. My interest is that over a year ago I sent my doctoral dissertation, a very large manuscript on the genus *Rorippa* to Dr. Shiners for publication in *Sida*, which he agreed to do. In addition, I offered $500.00 to help defray expenses for publication, and this was paid to *Sida* in two contributions of $250.00 each, one in December 1969 and one in December 1970. Thus I would hope that you and Dr. Thieret, or anyone else, could see to it that the present manuscript on hand and/or in press for *Sida* could be published, and certainly as a memo-

rial to Dr. Shinners. I would be willing to do most anything, at this distance, to help the cause along. I suspect financing is the big problem, and I would be willing to contribute some more funds, if I knew for sure my manuscript would be published in *Sida*. Furthermore, I suspect some editing or deletions of my manuscript could help. It was my understanding that the specimen citations would not be published.

I might also say that Mr. Robert Haynes, our assistant curator of the Herbarium, and former student of Dr. Thieret, has his manuscript on the genus *Conopholis* being published in *Sida*.

I would also like to see this fine journal for taxonomic botany and related interests be continued either by Southern Methodist University or by a federation of the south-central botanists, for example.

Mahler's letter (3 Mar 1971) back to Dr. Stuckey and again Dr. Thieret is involved:

"In regard to your letter of 24 February 1971, we are planning to continue SIDA and follow Dr. Shinner's plants for Vol. 4 (3) and (4). Issues 3 and 4 will be the papers as described in his letter of 26 March 1970.

You are being credited with a $500 contribution towards the publication of your MS. At this time, I cannot say what the financial situation will be in relation to SIDA and its $12 page costs (re Shinners' letter, 9 December 1969), but hopefully we can continue as planned by Dr. Shinners.

My continuing to work like Dr. Shinners did would be impossible with the other activities (duties). He did not get a chance to go over the MS. in detail and I would like to send it to a reviewer such as Dr. Thieret. Perhaps you would like to make the changes Dr. Shinners suggested first, and then send it to Dr. Thieret.

We have plenty of time in this respect as I do not expect No. 3 to come our till summer ('71) at this time.

I appreciate the briefing (previous correspondence) as it has been very helpful. I wish that everyone would do it this way. Perhaps they will as I have one other individual who has brought me up to date in the same manner.

The *Conopholis* paper of Haynes is still in the mill and status at this time unknown."

Dr. Stuckey's response:

"I enclose Xerox copies of two letters which show that Dr. Reed C. Rollins has read and reviewed my *Rorippa* manuscript. I am pleased that you have selected Dr. Thieret to go over my manuscript in preparation for its publication. It would be best if you transmitted the manuscript directly to him, rather than sending it back to me. The revision that Dr. Shinners mentioned involves a small item of about one page. I can do this and send the revision to Dr. Thieret. As you may know Dr. Thieret will be at our University for 5 weeks this summer teaching at Stone Laboratory. I will be there at the same time and can work with him on the manuscript at that time."

Mahler's letter (23 Mar 1971) to Dr. Stuckey and Dr. Thieret is mentioned:

"I found your MS. yesterday (still have not located the plates, but will in time) and received your letter today. Dr. Shinners had discussed this MS. with me and stated that it would have to be trimmed to ca. the length of Kral's paper 9ca. 175 pp.). As suggested by Shinners to you, ca. 150 pp. can be eliminated readily (the citation of specimens). That still leaves ca. 100 pp. (70 pp. of MS. + 30 maps, illus.) to be eliminated. This is one of the items of "reviewing" that I was referring to in regard to John Thieret. If you wish to do this yourself and possibly you should as it's your MS., John Thieret might be helpful in short cuts so that you will not leave out any essential material. The discussions, etc., are rather verbose and the same ideas could be expressed in fewer words."

1972—Thieret's letter (January 11, 1972) to Dr. Stuckey announcing his associate editorship:

SIDA, founded by Lloyd H. Shinners, is privately published by Wm. F. Mahler, SMU Herbarium, Dallas, Texas, 75222, U.S.A. Subscription price $8 (U.S.) per volume; parts issued at irregular intervals.

ASSOCIATE EDITOR
John W. Thieret
University of Southwestern Louisiana

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TAXONOMY AND DISTRIBUTION OF THE GENUS RORIPPA (CRUCIFERAE) IN NORTH AMERICA[1]

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Rorippa consists of those yellow-petaled, numerous-seeded, readily-dehiscent-fruited marsh and shore plants in the Cruciferae. Distributed primarily in temperate, less so in subtropical and tropical regions, the genus occurs on every continent except Antarctica, but the species are more numerous in the northern hemisphere. The number of valid species is usually given as between 40 and 50, but this number may increase to 60 or 70 with expanded knowledge. Jonsell (1968) considered there to be about 70 species, some imperfectly known. One highly variable species, *R. palustris*, is known from each continent where the genus occurs. Busch (1915) discussed and mapped seven species for Eurasia; Wannenmacher (1960) had eight species for Middle Europe, and, in *Flora Europaea*, Valentine (1964) included 10 species. Several species are known from southern Asia, Africa, and South America. I recognize 21 species and 25 varieties (including typical ones) as native to North America; seven species are considered as introduced. The evolutionary relationship of these foreign members to the North American species is not understood.

In North America, *Rorippa* is most common and abundant, both as to individuals and taxa, in the mountainous regions of western United States. The plants usually grow in open, damp or wet, naturally disturbed habitats along sandy shores of lakes and alluvial banks of creeks, streams, and rivers, and in marshes and swales; or in wet artificially-disturbed sites along roadside, drainage, and irrigation ditches, about edges of farm ponds, in low fallow or cultivated fields and gardens, along railroad grades and ditches, and about dumps or on ballast.

HISTORY OF THE GENUS

The yellow cresses have a confused nomenclatural history. *Rorippa* begins with Scopoli (Fl. Carn. ed. 1. 520. 1760), who wrote the first, but brief, generic diagnosis. Although he did not provide binomials, three species were named. The first contains the exact phraseology as that provided by Linnaeus (Sp. Pl. 675. 1753) for *Sisymbrium sylvestre*. Scopoli cited Linnaeus as one of five sources; on this basis, *Rorippa sylvestris* (Linnaeus) Besser is taken as the type of the genus. Abrams (1944) listed *Sisymbrium am-*

[1] Based on and revised from a doctoral dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in The University of Michigan, Ann Arbor, 1961. Contribution from the Botany Program (Paper No. 770) and The Herbarium of The Ohio State University.

Left: Copyright page of *Sida* 4(4), the first issue of *Sida* in which John Thieret was appointed associated editor. **Right:** First page of Ronald Stuckey's *Rorippa* article which John edited.

"Thanks for the answers to my several queries about your *Rorippa* ms. Mahler is really the one to talk to about any financial matters. When I finish with the ms., I shall return it to Mahler. From then on, any dealings will be conducted by him. I have just been asked to serve as Associate Editor of Sida—which is just about what I've been doing all along."

John Thieret came to the editorial rescue as associate editor of *Sida* in 1972 and for the next 34 years, John proudly and faithfully served the journal in so many different ways. Mahler along with John's superb editorial knowledge and skills and the help of many other colleagues, kept *Sida* going strong. Mahler passed the editorial baton to Lipscomb in 1983 but remained publisher until 1993; John was associate editor from 1972–2005.

1972–2005—Not only was John an active associate editor of *Sida*, he was also contributing manuscripts. Twenty-seven of John's papers were published in *Sida* during his 34 years of associate editorship. This represents almost 25% of all the papers John published in that same time frame. In fact, of all the scientific papers listed in Ralph Thompson's tribute (2006), 26% were published in *Sida*, more than three times that of the next closest journal. The amount of work he contributed is enormous and the success, the foundation that John Thieret (and Wm. F. Mahler) made to *Sida* cannot be underestimated. We all have been for-

tunate to have had John's involvement with the journal but my (Lipscomb) career was truly impacted by this good friend.

John's influence on my (Lipscomb) personal career

In the fall of 1975 my botanical career began as herbarium botanist at Southern Methodist University. There I worked in the great herbarium and botanical library built by the prolific researcher, writer and founder of *Sida*, Lloyd Shinners. My first two years of work at SMU were strictly herbarium related and I casually observed the editorial work on *Sida* by Wm. F. Mahler. In the beginning I did not know who John Thieret was but it didn't take me long to find out. Tradition is wonderful. Shinners told Mahler he needed to meet John and Mahler told me I needed to meet John. In 1977, two years into my job at SMU, I was appointed assistant editor of *Sida* by my mentor, friend, and colleague Bill Mahler. It was around this time—pre-email days—that I first began to communicate with "Big John" Thieret over the phone and through letters. Over time I began to interact with him more and more on *Sida*'s issues and editorial matters. It would be years later before I actually met the man behind the red pen. I had no idea John was the master of editing. I was too young to envision the immediate and future impact this one man would have on my life. He genuinely cared for me as an individual and shared his expertise and knowledge with me freely. Through John, a whole new world of wisdom and knowledge was available at my doorstep. John Thieret took me in almost as if I was one of his own children. He (and Mahler) helped me to learn the role of an editor one red pen at a time.

A few years passed before I finally got to meet John in person. He was everything that I envisioned. I enjoyed one full week with John and his lovely wife Mildred back in the late 1990s. I stayed in their home in Alexandria not far from Northern Kentucky University (Highland Heights) where John worked. It was in their home that I had my first meal of tef (*Eragrostis tef* (Zucc.) Trotter). It was also at the Thieret home that John taught me the word "kex" or "kexes" for a dead stalk or stalks of herbaceous plants, "especially of large umbelliferous plants" (Oxford English Dictionary). I enjoyed four wonderful days with John traveling and botanizing through northern and eastern Kentucky. One of the many botanical things I learned from John on that trip was the edible fruits of *Rhus typhina* (Staghorn Sumac). He told me the drink from the sweet fruits was called "rhusade." After returning to the Cincinnati area from out botanical field trip, John and I drove to one of his fun places to botanize called Jungle Jim's International Farmers Market in Fairfield (Cincinnati), Ohio. One quote I found on the web said, "It is the ultimate food shopping adventure." We walked into this humongous store and headed straight to the produce section and did we ever have a great time identifying plants and plant parts. It was an awesome experience with John, the economic botanist. And we visited another of John's

favorite plant places, Spring Grove Cemetery in Cincinnati. What an incredible place to study and learn about the many different woody plants and what a wonderful teacher I had.

For 33 years John Thieret served *Sida, Contributions to Botany* as associate editor. His crusading editorial and scientific contributions to *Sida* are beyond measure! He was a good friend and advocate of Lloyd Shinners and *Sida*; he was a solid anchor of support to Wm. F. Mahler in the storm of uncertainty that followed Lloyd's death; and he was a radiant lighthouse of editorial help to me as a young editor. He was the guiding light of editorial excellence and authority. *Sida* is today in large part because of John Thieret. His 33 years of editorship with *Sida* stands longer than anyone else associated with the journal.

John Thieret was my rock and my anchor. His editorial energy and enthusiasm and loyalty to *Sida* will forever be remembered and deeply appreciated! Did I ever say thank you John? I'm sure I did many times but let me say it in print in *Sida* one last time for everyone to see, **Thank you John** for all that you've done and continue to do through your teachings.

Postscript: Changes in the journal, Sida no more

I'm glad these tributes to John Thieret could be published in the journal that he loved so very much. Soon the journal *Sida, Contributions to Botany* will no longer be published by that name but instead will be called the *Journal of Botanical Research Institute of Texas*. The new journal will have a new look but generally the same format, botanical focus, and editorial direction will remain. The leadership of the Botanical Research Institute of Texas has decided the name "Sida" is offensive and has too much of a negative connotation because of its similarity to the word meaning AIDS in Spanish, French, Italian, and Portuguese. Perhaps the name change is a good thing but I am personally saddened to see Shinners' original and long-standing name displaced.

ACKNOWLEDGMENTS

I thank Gary Jennings (library/archive help), Ruth Ginsburg (archive help and reading the ms), and Ralph Thompson and Guy Nesom for helpful comments.

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A NEW NARROWLY ENDEMIC SPECIES OF *CLEMATIS* (RANUNCULACEAE: SUBGENUS *VIORNA*) FROM NORTHEASTERN TEXAS

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ABSTRACT

Clematis carrizoensis, a new narrowly endemic species of subgenus *Viorna*, is described from the Carrizo Sands of northeastern Texas. This species belongs to a complex of similar species characterized by glaucous and glabrous abaxial leaf surfaces and stems. Four additional species comprise this complex: *C. addisonii*, *C. glaucophylla*, *C. texensis*, and *C. versicolor*. *Clematis carrizoensis* is morphologically most similar to the scarlet sepaled *C. texensis* and the purplish-red to bluish-lavender sepaled *C. versicolor*. It differs from those two species in having yellowish-cream and lightly lilac-tinged sepals. From *C. addisonii* and *C. glaucophylla*, *C. carrizoensis* differs in sepal color and in having thicker and more reticulate leaves. All five species of the complex are allopatric and occupy somewhat different habitat types in different physiographic provinces. Further discussion of their morphological differences, geographic distribution, and habitat preferences is provided.

RESUMEN

Se describe ***Clematis carrizoensis***, una nueva especies del subgénero *Viorna*, endémica de Carrizo Sands en el noreste de Texas. Esta especie pertenece a un complejo de especies similares caracterizadas por tener los tallos y el envés glaucos y glabros. El complejo tiene otras cuatro especies: *C. addisonii*, *C. glaucophylla*, *C. texensis*, y *C. versicolor*. *Clematis carrizoensis* es la más similar morfológicamente a *C. texensis* de sépalos escarlata y *C. versicolor* de sépalos que van del rojo púrpura al lavanda azulado. Difiere de estas dos especies por tener los sépalos amarillo crema ligeramente teñidos de lila. De *C. addisonii* y *C. glaucophylla*, se diferencia *C. carrizoensis* por el color de los sépalos y por tener las hojas más gruesas y más reticuladas. Las cinco especies del complejo son alopátricas y ocupan diferentes hábitats en provincias fisiográficas diferentes. Se ofrece una discusión sobre sus diferencias morfológicas, distribución geográfica, y preferencias de hábitat.

In North America, 18 species of *Clematis* (Ranunculaceae) belong to the subgenus *Viorna* (Pringle 1997). Of these, eight currently recognized species were included in the formerly recognized *Clematis* section *Viorna* subsection *Viornae* (Erickson 1943; Dennis 1976; Kral 1987): *C. addisonii* Britton, *C. glaucophylla* Small, *C. morefieldii* Kral, *C. pitcheri* Torr. & A. Gray, *C. reticulata* Walter, *C. texensis* Buckley, *C. versicolor* Small, and *C. viorna* L. These species are perennial vines characterized by relatively large (1–3 cm) urceolate flowers with thick leathery sepals that are mostly arranged in solitary or few-flowered cymes borne

on axillary peduncles subtended by leafy bracts (Dennis 1976). These taxa can be delineated into two groups based on leaf vestiture (Dennis 1976). The first group including *C. morefieldii*, *C. pitcheri*, *C. reticulata*, and *C. viorna* all have variously pubescent abaxial leaf surfaces and stems. The species of the second group, characterized by glabrous and glaucous abaxial leaf surfaces and stems, include *C. addisonii*, *C. glaucophylla*, *C. texensis*, and *C. versicolor*. These species form a complex here referred to as the *C. glaucophylla* complex.

The species of the *C. glaucophylla* complex can be distinguished from each other by relatively few qualitative morphological characteristics. Often, a combination of features, including morphology, habitat, and distribution, must be used to identify taxa. Several structures including the caudex, roots, inflorescences, and achenes offer little or no taxonomic value in separating most species of the complex (Erickson 1943; Dennis 1976). The most taxonomically useful traits are leaf texture, degree of leaf vein reticulation, and sepal color, although even these characters exhibit considerable variation and intergradation (Erickson 1943; Dennis 1976). For instance, leaf thickness is useful when extremes are exhibited, but Dennis (1976) noted that factors such as leaf age and environmental conditions often make it a difficult character to assess. Similarly, degree of vein reticulation is a useful character when found in its extremes but it can be confounding when trying to evaluate the continuum between extremes (Dennis 1976). Erickson (1943) concurred, noting that while reticulate venation is a valuable taxonomic character, "it is not often possible to distinguish between degrees of reticulation consistently." Dennis (1976) considered sepal color to be important for distinguishing species of the complex; for example thin-leaved specimens of *C. versicolor* can only be distinguished from *C. glaucophylla* by sepal color. Other characteristics, including degree of leaf dissection, leaflet shape, flower shape, and stamen vestiture, are only generally useful for distinguishing species and are apparently never diagnostic. While the species of the *C. glaucophylla* complex may be difficult to differentiate morphologically, all members of the complex exhibit specific physiographic preferences (Dennis 1976) and have non-overlapping ranges (Fig. 1).

Clematis texensis and *C. versicolor* are completely allopatric with the former restricted to the Edward's Plateau of Texas and the latter confined to the Interior Highlands (Arkansas, Missouri, Oklahoma) and Interior Low Plateaus (Alabama, Kentucky, Tennessee). They differ consistently in flower color and generally in leaf dissection and leaflet shape. Both species usually have relatively thick and conspicuously reticulate leaves. Erickson (1943) called attention to possible intermediate populations occurring in the region between the Interior Highlands and the Edward's Plateau noting that some specimens from this region have been difficult to assign to a particular species. Erickson arbitrarily referred questionable specimens from southwestern Arkansas and southeastern Oklahoma to *C. versicolor* and specimens from northeastern Texas (Smith

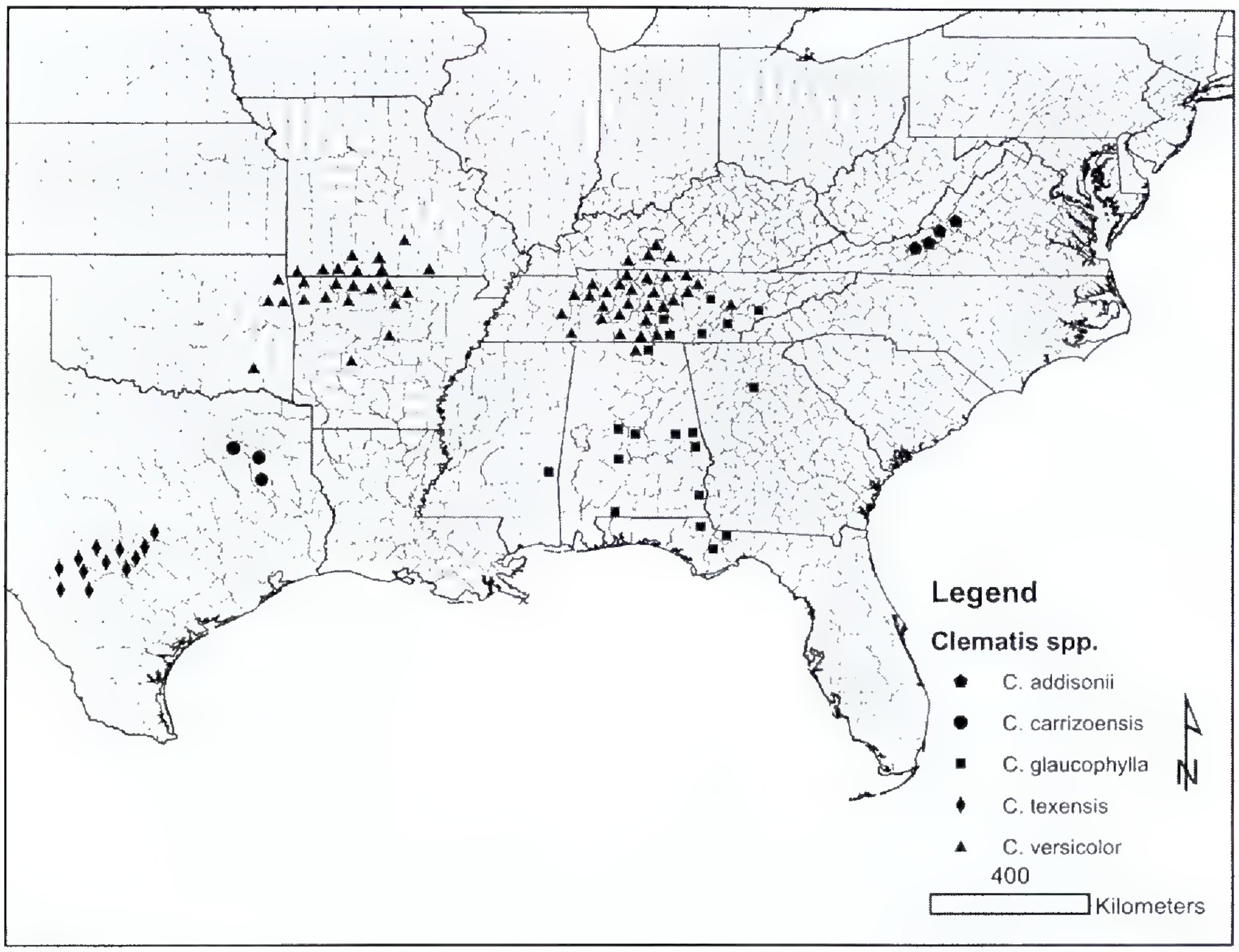


FIG. 1. Geographic ranges of the five species of the *Clematis glaucophylla* complex. (Adapted from Dennis 1976)

County) to *C. texensis*. Dennis (1976) contended that the Texas specimens were not *C. texensis* because the sepals were white to pale lavender rather than the bright red characteristic of that species. Interestingly, Dennis (1976) referred the Texas plants to *C. versicolor* in spite of the fact that they also differed from that species in sepal color and habitat and occurred in a different physiographic region ca. 200 km from the nearest known *C. versicolor* population. Additional study of herbarium specimens from this region coupled with field work has revealed that the Texas populations previously referred to *C. versicolor* actually represent a new species described below.

Clematis carrizoensis D. Estes, sp. nov. **(Figs. 2, 3, 4B)**. TYPE: U.S.A. TEXAS: Smith Co.: 1.5 mi NW of Lindale, sandy soil, vine growing along fence near roadside, 15 May 1949, *J.F. Hennen 408*, consists of 2 sheets (HOLOTYPE: SMU).

A Clematide versicolore sepalis e lilacinis flavidis-cremeis, foliis plerumque dissectioribus, foliolis saepiuscule emarginatis ad apices profundius cordatis basibus differt.

Perennial trailing or scandent **vines** to 3 m long, from a woody caudex bearing numerous smooth fleshy apparently unbranched roots. **Stems** stout proximally, slightly flexuous distally, 6 angled, 12 ribbed, glabrous and glaucous, reddish-brown to pale brown. **Leaves** oppositely decussate, imparipinnate to pinnate-



FIG. 2. Holotype (*J.F. Hennen 408*, SMU) of *Clematis carrizoensis*.



FIG. 3. *Clematis carrizoensis*. **A.** Portion of plant showing glaucous abaxial leaf surfaces. **B.** Close-up of abaxial surface of leaflet showing raised-reticulate venation. **C.** Flower, front view (note crispate sepal margins). **D.** Fruit. Photos above are from plants collected at same site as *D. Estes 07032*.

ternate, largest at about mid-stem, spreading, to 2.0 dm long, longer than wide to as wide as long; petiole stout, equaling or more frequently shorter than the lowest leaflets, to 6.0 cm long, glabrous and glaucous, base of opposing petioles usually connate; rachis geniculate; leaflets symmetrical or asymmetrical, paired, 8–10 on imparipinnate leaves, to 25 on proximal-most pinnate-ternate leaves, spreading to erect, reduced distally on rachis, the distal-most often form-

ing a short simple tendril, proximal-most entire or 2–3-lobed to trifoliate, ovate, broadly ovate, or subrotund, leaflets to 7.0 cm long and to 6.0 cm wide, coriaceous, base shallowly to deeply cordate, rounded, or truncate, margins slightly revolute, leaflet apices and lobe apices rounded, retuse, or occasionally acute, mucronate, adaxial and abaxial surfaces strongly reticulate with all vein orders conspicuously raised, forming an intricate reticulum, light green adaxially, paler abaxially, drying pale olive-brown to olive-green, glabrous and glaucous on both surfaces but more conspicuous on abaxial surface; petiolules 1.5–3.0(–7 cm) long, one-fourth to one-third length of leaflet or rarely one-half to as long as leaflet, stout, glabrous and glaucous. **Flowers** solitary on long axillary peduncles or rarely axillary and terminal, nodding, ovoid or urceolate; peduncles erect, curved or frequently abruptly recurved at apex, 7.5–17.0 cm long, stout, glabrous and glaucous, with 2 foliose bracts; bracts sessile or subsessile with petioles to 4.0 mm, positioned mostly near the middle of the peduncle, base subcordate to deeply cordate, margins entire or 2–3-lobed, otherwise similar in shape, size, texture, and vestiture to leaflets. **Sepals** erect, connivent, ovate-lanceolate to oblong-ovate, apices reflexed, 1.8–3.0 cm long, 0.7–1.3 cm wide, coriaceous, ca. 12 nerved, abaxially yellowish-cream, or greenish-yellow and often faintly tinged with lilac proximally, adaxial surface similar in color to the abaxial surface at least distally, mostly drying tan or light brown, edges narrowly crispate, white-tomentulose, abaxial and adaxial surfaces glabrous. **Stamens** linear, 1.8–2.4 cm long, the filaments flattened, in dried material dark brownish-red in the proximal half, densely pilose from below middle to apex, anthers 6.0 mm long, connective extended 1.75–2.0 mm beyond anthers, pilose. **Fruit** tightly clustered in spherical heads 4.5–8 cm in diameter, light brown, body rhomboidal-ovate, 6.0–9.0 mm long and 6.0–7.0 mm wide, acuminate at both ends, compressed, marginally thickened, sericeous; style curvate, 3.0–5.5 cm long, with a yellowish-brown plumose coma, hairs of coma spreading to ascending, to 3.0 mm long. Chromosome number unknown.

Additional specimens examined: **TEXAS: Cherokee Co.:** ca. 9.5 mi E of Troup, ca. 6 mi W of Price, ca 3.5 mi N of Hwy 13, sandylands, 12 Jul 1977, *G. Ajilvsgi 5038* (BRIT) **Smith Co.:** sandy woods east of Swan, 16 May 1902, *J. Reverchon 2962* [two sheets] (MO); on R.R. [railroad] near Lindale, Apr 1923, *J. Reverchon s.n.* (MO); western Tyler along Cotton Belt Railway, east end of Pine Burr Rd., infrequent at edge of woods along railway, 21 May 1949, *V.L. Cory 56212* (SMU); western Tyler, S of Pine Burr Rd, infrequent in sandy woods, 10 Aug 1950, *V.L. Cory 57860* (SMU); just N of Interstate 20 in woods E of Old Tyler-Mineola Rd., 20 Oct 1965, *D.S. Correll & H.B. Correll 32041* (LL); sandy field with scattered post oak in SW angle where US Rte. 69 and Loop 323 intersect, north edge of Tyler, 28 Aug 1966, *D.S. Correll 33513* (LL); pure sand in field on Loop 323 near intersection with Rte. 69, Tyler, 6 Jun 1969, *D.S. Correll 37401* (LL); in SW angle of intersection of US 69 and Loop 323, N edge of Tyler, under oaks next to 12 Oaks Motor Hotel, growing in sandy field under *Quercus incana*, *Q. margaretta*, with *Opuntia*, *Yucca*, 22 Jun 1975, *W.M. Dennis 51718* (TENN); NW portion of city of Tyler, 0.75 km WSW of junction of TX State Hwy 323 Loop and US Hwy 69, ca. 20 m SW of junction of Hwy 323 Loop and Silver Creek Dr., 32°22'42.1"N, 95°20'20.6"W, along N edge of scrubby oak-hickory woods and in a small opening nearby, rooted in deep sand and scrambling over small shrubs and herbs, with *Quercus*



FIG. 4. Flowers of *Clematis texensis* (**A**), *Clematis carrizoensis* (**B**), and *Clematis versicolor* (**C**).

spp., *Carya*, *Rhus aromatica*, *Prunus gracilis*, and *Toxicodendron pubescens*, 9 May 2005, *D. Estes 07032* (GH, NY, TENN, VDB). **Van Zandt Co.:** 2.3 mi E of Ben Wheeler, sandy loam, 6 May 1951, *R. Van Vleet 1257* (SMU).

Distribution and Habitat.—*Clematis carrizoensis* is endemic or nearly endemic to the Carrizo Formation, a narrow zone (19 km wide) of relatively deep deposits of coarse to find sand that trends southwest to northeast for ca. 720 km from south-central to northeastern Texas (Macbryde 1933; Sorrie and Weakley 2001). Sorrie and Weakly (2001) identified an additional 12 taxa endemic or nearly endemic to this formation. Within the Carrizo Sands, *C. carrizoensis* has only been collected from three contiguous counties, Cherokee, Smith, and Van Zandt, all in the northeastern section of the formation. *Clematis carrizoensis* grows in or along the edges of open, well-drained, prairie-like areas in full sun or partial shade. Within these communities, *C. carrizoensis* trails along the ground or over low herbs, shrubs, or fences, apparently rarely climbing higher into low branches of trees. Oak-hickory woodlands or thickets border these sites. Dominant tree species associated with one population of *C. carrizoensis* in Tyler, Texas (site of *D. Estes 07032* cited above) include *Quercus incana* Bartr., *Q. marilandica* Muench., *Q. nigra* L., *Q. stellata* Wang., *Carya texana* Buckl., *Sassafras albidum* (Nutt.) Nees, and *Ulmus crassifolia* Nutt. Frequent small trees, shrubs and woody vines were *Opuntia* sp., *Prunus caroliniana* (P. Mill.) Ait., *P. gracilis* Engelm. & A. Gray, *Rhus aromatica* Ait., *R. copallinum* L., *R. glabra* L., *Rubus trivialis* Michx., *Stillingia sylvatica* Garden ex L., *Toxicodendron pubescens* P. Mill., *Vaccinium arboreum* Marsh., *Viburnum rufidulum* Raf., *Vitis mustangensis* Buckl., *V. rotundifolia* Michx. and *Yucca* sp. *Baptisia* sp., *Cnidoscolus texanus* (Muell.-Arg.) Small, *Croton argyranthemus* Michx., *Mimosa* sp., *Paronychia drummondii* Torr. & A. Gray, *Pteridium aquilinum* (L.) Kuhn, *Rumex hastatulus* Baldw.,

Schizachyrium scoparium (Michx.) Nash and *Talinum rugospermum* Holzinger were closely associated herbaceous taxa.

Phenology.—*Clematis carrizoensis* flowers from early May to early August; fruits are produced beginning in late June and persist until November.

Etymology.—The specific epithet "*carrizoensis*" was selected in honor of the Carrizo Sands, the geologic formation to which *C. carrizoensis* is apparently restricted.

Common Names.—Carrizo sands leather-flower; sand clematis

Conservation Significance.—*Clematis carrizoensis* is a rare species. I have seen only 12 specimens from three counties in northeastern Texas; 10 of these are from just four sites in a small area of Smith County. Label data from herbarium specimens also indicate that this species is uncommon where it occurs. Most of the specimens examined for this study were collected over 30 years ago possibly indicating that this species is declining or simply overlooked. Most of the populations represented by collections are located near or in the city of Tyler, Texas. These populations may be subject to extirpation by future development. This species should be searched for in other sandy sites, particularly those associated with the Carrizo Formation, in northeastern Texas as well as in sandy habitats in nearby portions of Miller County, Arkansas and Caddo Parish, Louisiana. This species should be considered endangered and should be afforded protection at both the state and federal level.

Species of the *Clematis glaucophylla* Complex

Five species comprise the *C. glaucophylla* complex. While all species differ in rather subtle morphological characteristics, they are all allopatric and mostly inhabit different plant communities in different physiographic provinces. The complex is in need of a detailed phylogenetic study.

Clematis addisonii, a narrow endemic of a four county area in the Ridge and Valley of western Virginia (Fig. 1), inhabits dry calcareous woods and outcrops (Kral 1983). It is characterized by a mostly erect, non-twining habit, mostly simple, thin, and inconspicuously reticulate cauline leaves, and solitary terminal flowers that have purple to reddish-purple sepals with whitish apices.

Clematis glaucophylla ranges from northwestern Florida west to southeastern Mississippi and north to southeastern Tennessee (Fig. 1); it is reportedly disjunct to McCurtain County, Oklahoma (Dennis 1976). Reports of *C. glaucophylla* from Kentucky (Jones 2005) are based on misidentified specimens (D. Estes, pers. obs.). Throughout most of its range in the Piedmont and Gulf Coastal Plain, *C. glaucophylla* grows in sandy neutral to slightly acidic soils along streams (Dennis 1976), but at some sites in Alabama and southeastern Tennessee, *C. glaucophylla* grows at the edges of dry rocky calcareous forests (D. Estes, pers. obs.). *Clematis glaucophylla* has a viny habit and compound cauline leaves that have mostly thin and inconspicuously reticulate leaflets. The proximal leaf-

lets are often deeply lobed, divided, or ternate. Flowers of *C. glaucophylla* are borne on axillary peduncles and have sepals that are cherry-red or reddish-purple abaxially and light colored near the abaxial tip and on the whole surface adaxially.

Clematis texensis is endemic to the Edward's Plateau of Texas (Fig. 1) where it is often associated with calcareous woodlands, edges, cliffs, and stream banks. The species has a viny habit and compound cauline leaves with relatively thick and conspicuously reticulate leaflets. The proximal leaflets vary from simple to lobed or ternate. The flowers are borne on axillary peduncles and the sepals are scarlet or rose-red abaxially and near the tip adaxially (Fig. 4).

Clematis versicolor has a bicentric distribution with part of its range centered in the Interior Highlands of southwestern Missouri, western Arkansas, and eastern Oklahoma and the other portion centered in the Interior Low Plateau of central Tennessee, extreme northern Alabama, and south-central Kentucky (Fig. 1). It is usually associated with calcareous bluffs, dry woods, and roadsides with exposed limestone. *Clematis versicolor* has a viny habit, relatively thick and conspicuously reticulate compound cauline leaves with the proximal leaflets entire or rarely lobed or divided, and flowers borne on axillary peduncles. The abaxial surfaces of the sepals of *C. versicolor* are mostly purplish-red proximally and often are cream-colored or greenish distally (Fig. 4).

Clematis carrizoensis is restricted to sandy prairie-like areas among oak-hickory woodlands in three counties in northeastern Texas (Fig. 1). The species has a viny habit, thick and conspicuously reticulate compound leaves that have proximal leaflets frequently lobed, divided, or ternate, flowers borne on axillary peduncles, and sepals that are abaxially yellowish-cream and faintly tinged with lilac proximally (Fig. 4).

Characters Useful for Distinguishing Members of the *Clematis glaucophylla* Complex

The members of the *C. glaucophylla* complex can be distinguished by differences in habit, leaf dissection, leaf texture, leaflet shape, degree of vein reticulation, flower position, sepal color, habitat, and geography (Table 1; Fig. 1).

In terms of habit, *C. addisonii* is the only erect non-viny member of the complex. It has stems that are mostly less than 1 m tall whereas the other species in the complex have viny stems mostly greater than 1 m in length. Dennis (1976) noted that while *C. addisonii* is the only species in the complex that exhibits this growth form, occasional individuals of *C. addisonii* bear apical branches that often become entangled and approach a viny habit.

Leaf dissection is a character that is only generally useful for distinguishing species of the complex, the exception being *C. addisonii*. *Clematis addisonii* has leaves that are mostly simple but occasionally vary to pinnate with up to six leaflets. The rest of the species of the complex have leaves that are pinnate

TABLE 1. Characteristics of the *Clematis glaucophylla* complex, compiled from data presented in Dennis (1976) and Pringle (1997).

	texensis	**carrizoensis**	**versicolor**	**addisonii**	**glaucophylla**
Habit	viny, > 1 m	viny, > 1 m	viny, > 1 m	erect, < 1 m	viny, > 1 m
Leaf Dissection	1-pinnate to pinnate-ternate, proximal leaflets commonly lobed or 3-foliate	1-pinnate to pinnate-ternate, proximal leaflets commonly lobed or 3-foliate	1-pinnate, proximal leaflets mostly unlobed, occasionally 2–3 lobed	simple, or distal leaves 1-pinnate	1-pinnate to pinnate-ternate, proximal leaflets commonly lobed or 3-foliate
Leaf Texture	coriaceous	coriaceous	coriaceous	thin	thin
Venation	reticulate, raised	reticulate, raised	reticulate, raised	not reticulate, not raised	not reticulate, not raised
Flower Position	mostly axillary	mostly axillary	mostly axillary	mostly terminal	mostly axillary
Flower Color	scarlet to rose-red	yellowish-cream, lilac-tinged proximally	purplish-red to bluish-lavender, creamy or greenish distally	purple to purplish-red, whitish distally	cherry red to reddish-purple

to pinnate-ternate with more than six leaflets. The degree of compounding of the proximal leaflets is a useful yet non-diagnostic character that according to Erickson (1943) "must be used with judgment." For example, Erickson (1943) noted that leaf dissection may generally be used to separate *C. texensis* and *C. versicolor*. *Clematis glaucophylla*, *C. texensis*, and *C. carrizoensis* frequently have lobed, divided, or ternate proximal leaflets whereas the proximal leaflets of *C. versicolor* are usually unlobed or rarely lobed or ternate.

Erickson (1943) considered leaflet shape to be of general use in delimiting taxa, especially the leaflet apices. Generally, *C. addisonii*, *C. glaucophylla*, and *C. versicolor* have broadly to narrowly obtuse leaflet apices. *Clematis texensis* and *C. carrizoensis* have leaflet apices that are more frequently emarginated apically but that vary to obtuse. Leaflets of *C. carrizoensis*, *C. texensis*, and *C. versicolor* are almost always mucronate at the apex.

Among the species of the *C. glaucophylla* complex, two groups can be delineated based on leaf texture and degree of leaf vein reticulation. *Clematis glaucophylla* and *C. addisonii* belong to a group characterized by relatively thin and non-reticulate leaves. The other group, consisting of *C. carrizoensis*, *C. texensis* and *C. versicolor*, has relatively thick and conspicuously reticulate leaves. Once again, these characters are relative and are hard to differentiate when only one species is encountered and can sometimes be difficult to assess

from herbarium material. Furthermore, shade plants of all species of the complex may be thin and non-reticulate.

Flower position is a character that is of limited taxonomic value in the *C. glaucophylla* complex. Most species have flowers borne on axillary peduncles; however, *C. addisonii* has flowers that are mostly borne on terminal peduncles.

Perhaps one of the most useful characters for distinguishing the members of the *C. glaucophylla* complex is sepal color (Table 1, Fig. 4). Unfortunately, it is also the character that is most difficult to preserve and interpret on herbarium specimens. In *C. glaucophylla*, the sepals are more frequently cherry red to reddish-purple abaxially except distally they are often light colored. *Clematis texensis* has sepals that are generally scarlet or rose-red, and the red coloration is present on both the abaxial surface and on the distal portion of the adaxial surface. Compared to *C. glaucophylla* and *C. texensis*, the sepals of *C. addisonii* are more purplish, varying from light purple to purplish-red with whitish apices. Typical specimens of *C. versicolor* have sepals that are purplish-red or bluish-lavender proximally and cream-colored or greenish distally. The sepals of *C. carrizoensis* are yellowish-cream and lightly tinged with lilac proximally.

Habitat can be used to distinguish the species of the *C. glaucophylla* complex to some extent. *Clematis addisonii*, *C. texensis*, and *C. versicolor* are apparently obligate calciphiles. *Clematis glaucophylla* is a facultative calciphile. *Clematis carrizoensis* is not associated with calcareous rock outcrops but rather is restricted to deep sandy soils. All of the species seem to grow best in edge habitats; however *C. addisonii*, *C. texensis*, and *C. versicolor* are sometimes found in closed-canopy forests.

When incomplete or non-flowering specimens of species of the *C. glaucophylla* complex are encountered, the most reliable character that can be used to distinguish the species is geography. All of the taxa are allopatric. The ranges of *C. versicolor* and *C. glaucophylla* abut one another in portions of southeastern middle Tennessee and possibly extreme northern Alabama. *Clematis texensis* and *C. carrizoensis* are restricted to Texas and *C. addisonii* is restricted to Virginia. *Clematis versicolor* is found only in portions of Oklahoma, Arkansas, Missouri, Kentucky, Tennessee, and Alabama; it should be also searched for in extreme northeastern Mississippi (Tishomingo Co.) and in extreme southern Illinois. *Clematis glaucophylla* occurs in Mississippi, Alabama, Georgia, Florida, and Tennessee. Alabama and Tennessee are the only two states that support more than one species of the complex.

KEY TO THE SPECIES OF THE *CLEMATIS GLAUCOPHYLLA* COMPLEX (ADAPTED FROM ERICKSON 1943, DENNIS 1976, AND PRINGLE 1997)

1. Plants ascending to erect, sometimes branched above, rarely viny; middle and lower cauline leaves mostly simple; flowers mostly terminal; restricted to Ridge and Valley Province of western Virginia _____ **C. addisonii** Britton

1. Plants scrambling or climbing, viny; middle and lower cauline leaves compound; flowers axillary; species not of Virginia.
   2. Leaves usually thin, adaxial surface without raised secondary and tertiary veins _____ **C. glaucophylla** Small
   2. Leaves usually thick, adaxial surface with moderately to prominently raised secondary and tertiary veins.
      3. Abaxial surface of sepals scarlet to rose-red or yellowish-cream and lightly lilac tinged; leaflets mostly ovate to subrotund, base mostly subcordate to deeply cordate, apex usually emarginated; lower leaflets commonly 2–3-lobed or 3-foliate; plants restricted to Texas.
         4. Sepals scarlet to rose-red abaxially; stamens not densely or uniformly pubescent, connective mostly glabrous or with a few stiff trichomes; plants of limestone uplands of the Edwards's Plateau in south-central Texas _____ **C. texensis** Buckley
         4. Sepals yellowish-cream abaxially and lightly tinged with lilac; stamens densely and uniformly pubescent, connective moderately to densely pubescent; plants of deep sandy habitats of northeastern Texas _____ **C. carrizoensis** D. Estes
      3. Abaxial surface of sepals purplish-red or bluish-lavender proximally and cream-colored or greenish distally; leaflets mostly ovate to elliptic, base obtuse to subcordate, apex mostly obtuse; lower leaflets mostly unlobed and undivided, infrequently lobed or ternate; plants of the Interior Highlands of Missouri, Oklahoma, and Arkansas and the Interior Low Plateau of Tennessee, Kentucky, and Alabama _____ **C. versicolor** Small

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Announcement

The Rupert Barneby Award

The New York Botanical Garden is pleased to announce that Rodrigo Duno de Stefano, of the Centro de Investigación Científica de Yucatán A. C. (CICY), is the recipient of the **Rupert Barneby Award** for the year 2006. He will be studying the family Leguminosae in the Yucatan Peninsula Biotic Province (YPBP), Mexico. With about 60 genera and more than 260 species there, the Leguminosae are one of the most important plant elements of the Yucatan region. This study will also contribute to a revision of four legume genera for the "Illustrated Flora of the Yucatan Peninsula" (G. Carnevali, general editor).

The New York Botanical Garden now invites applications for the **Rupert Barneby Award** for the year 2007. The award of US$ 1,000.00 is to assist researchers to visit The New York Botanical Garden to study the rich collection of Leguminosae. Anyone interested in applying for the award should submit their curriculum vitae, a detailed letter describing the project for which the award is sought, and the names of 2–3 referees. Travel to the NYBG should be planned for sometime in the year 2007. The application should be addressed to Dr. James L. Luteyn, Institute of Systematic Botany, The New York Botanical Garden, 200th Street and Kazimiroff Blvd., Bronx, NY 10458-5126 USA, and received no later than December 1, 2006. Announcement of the recipient will be made by December 15th.

Anyone interested in making a contribution to
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HILL CANE (*ARUNDINARIA APPALACHIANA*), A NEW SPECIES OF BAMBOO (POACEAE: BAMBUSOIDEAE) FROM THE SOUTHERN APPALACHIAN MOUNTAINS

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ABSTRACT

A newly recognized species of *Arundinaria* from the southern Appalachian Mountains is described, illustrated, and compared with the related species *A. gigantea* and *A. tecta*. **Arundinaria appalachiana** is distinguished by a combination of vegetative morphological characters including features of branching and leaf morphology, leaf anatomy, and ecology. Recognition of this species is consistent with genetic data that provide evidence for monophyly of the species and its sister relationship with *A. tecta*. A key for the identification of *Arundinaria* species in North America is included along with a comparative table based on morphology, leaf anatomy, and ecology.

KEY WORDS: bamboo, *Arundinaria*, eastern U.S., Appalachian Mountains

RESUMEN

Se describe e ilustra una nueva especie de *Arundinaria* del sur de la Cordillera de los Apalaches y se la compara con las especies relacionadas *A. gigantea* y *A. tecta*. Se distingue **Arundinaria appalachiana** por una combinación de caracteres morfológicos vegetativos, entre ellos aspectos de la ramificación, morfología y anatomía de las hojas, y ecología. El reconocimiento de esta especie concuerda con datos genéticos que apoyan la monofilia de la especie nueva y su posición como especie hermana a *A. tecta*. Se incluye una clave para la identificación de especies de *Arundinaria* en América del Norte y una tabla comparativa basada en la morfología, anatomía de las hojas, y ecología.

PALABRAS CLAVES: bambú, *Arundinaria*, este de los Estados Unidos, la Cordillera Appalachiana

INTRODUCTION

Arundinaria Michx. is a genus of north temperate woody bamboos (Poaceae: Bambusoideae) with a complex taxonomic history involving numerous entities that have been placed within it at one time or another over the past two

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hundred years (McClure 1973; Li 1997; Judziewicz et al. 1999), with older treatments including upwards of 400 heterogeneous species from Asia, Africa, and the Americas. Currently *Arundinaria* is treated in a restricted sense to include only those species endemic to the eastern United States (Ohrnberger 1999), but debate continues regarding the inclusion of certain Asiatic taxa (e.g., *Pleioblastus* Nakai, *Pseudosasa* Makino ex Nakai, *Bashania* P.C. Keng & Yi, and *Oligostachyum* Z.P. Wang & G.H. Ye) that share key morphological features with the North American species (Li 1997; Judziewicz et al. 1999). However, because *Arundinaria gigantea* (Walter) Muhl. is the type species for the genus, its generic placement is secure. As such, *Arundinaria* represents the only bamboos native to North America and the only temperate bamboos (the North Temperate clade of Clark et al., in press; Zhang & Clark 2000; Kelchner & Clark 1997) native to the New World, and provides another example of the classic disjunction pattern in the flora of eastern Asia and eastern North America (Wen 1999). With a species richness ratio of approximately 20:1 up to 90:1, depending on which Asian group is used for comparison within the North Temperate bamboo clade, *Arundinaria* and allies also provide an example of the intriguing asymmetry within this disjunction discussed by Guo and Ricklefs (2000).

Arundinaria s.s. encompasses arborescent or subarborescent woody bamboos with leptomorphic (running) rhizomes, persistent to deciduous and mostly glabrous culm leaves, and leaves at the tip of new shoots crowded into a distinctive fan-shaped cluster or top knot with blades expanded as on foliage leaves. Branch complements typically have 1 primary branch and 0–2 subequal secondary branches arising from shortened internodes at the base of the primary branch, which rebranch to produce up to 40 or more secondary branches on older culms. The culm and foliage leaves bear fimbriae and usually also auricles. Synflorescences in this group are determinate, open, and racemose or paniculate, with 6–12 laterally compressed florets per spikelet. Spikelets have 1–2 glumes and 3 stamens per floret. Like most temperate bamboos, *Arundinaria* has a basic chromosome number of $x = 12$ and presents several enigmatic characteristics including delayed flowering and monocarpy; reproduction is primarily vegetative and seed production is infrequent and unpredictable. *Arundinaria* s.s. is confined to southeastern portions of the continental United States (specifically Alabama, Arkansas, Delaware, Florida, Illinois, Indiana, Kentucky, Louisiana, Maryland, Mississippi, Missouri, New Jersey, North Carolina, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia), occurring from the Coastal Plain from New Jersey south to Florida and west to eastern Texas, and inland through the Piedmont to moderate elevations in the Appalachian Mountains. *Arundinaria* once formed extensive and dense canebrakes (with or without tree canopy) covering vast areas of fertile river bottomland often described by early explorers in the pre-colonial U.S. (West 1935), but has been greatly reduced in extent and abundance from

its historical range by grazing and fire suppression (Hughes 1951, 1957, 1966; Platt & Brantley 1997; Judziewicz et al. 1999).

Two species (*Arundo gigantea* Walter, *Arundo tecta* Walter) were originally described by Walter (1788) and represent extremes of morphological types found among inland and coastal forms, sometimes referred to as "Mississippi-type" and "Atlantic-type" (*sensu* Gilly 1943). *Arundinaria gigantea* (Walt.) Muhl. (river cane or giant cane) forms extensive colonies in low woods, moist ground, and along riverbanks from the lowlands east of the Appalachians, west to Missouri, up the Mississippi Valley to southern Illinois and up the Ohio River to southern Ohio. *Arundinaria tecta* (Walt.) Muhl. (switch cane) forms colonies in non-alluvial swamps, moist pine barrens, live oak woods and along sandy margins of streams, preferring moister sites than *A. gigantea*. It is restricted to the Coastal Plain of the southeastern U.S., from southern Maryland to Alabama and Mississippi (McClure 1973; Hitchcock 1951).

Within *Arundinaria s.s.*, complex population-level variation has continued to be problematic for taxonomists and field botanists (McClure 1973; Judziewicz et al. 1999; Platt & Brantley 1997). Phenotypic diversity among North American cane populations has inspired diverse taxonomic interpretations, generally with 1–3 taxa recognized at either specific or subspecific levels (Gilly 1943; Young & Haun 1961; Voight & Mohlenbrock 1964; Radford et al. 1968; Hitchcock 1971; McClure 1973; Campbell 1985; Tucker 1988; Platt & Brantley 1997). McClure (1973) published the most recent exhaustive treatment of *Arundinaria* and took a conservative approach, recognizing a single polymorphic species (*A. gigantea*) and three subspecies, one of which [*A. gigantea* ssp. *macrosperma* (Michx.) McClure] is a catch-all for putative hybrids derived from the introgression of the other two. However, McClure acknowledged that further studies, particularly genetic-based studies, were necessary to clarify the phylogeny and taxonomy of this group.

In the Southern Appalachians, astute botanical observers have long questioned the identity of a curious short-statured cane that typically occupied sites away from streams and rivers. Among the diverse North American populations of *Arundinaria*, a variety with deciduous foliage was recorded by botanist C.D. Beadle in Western North Carolina (Beadle 1914; see also Young 1945). Beadle recognized this form as *A. tecta* var. *decidua*, not ruling out the possibility that it might in fact be a distinct species. It is unclear why Beadle associated this deciduous variety with *A. tecta*, although perhaps it was because of the small stature typically associated with *A. tecta*. In the first half of the nineteenth century, two botanists affiliated with the University of North Carolina Herbarium, William Willard Ashe and William Chambers Coker, made notes on specimens collected near Highlands, North Carolina indicating that the short, delicate, deciduous cane of the mountains might be a distinct taxon. Roland Harper (1928) was also intrigued by cane specimens occurring on bluffs in northern

Alabama and thought that an unrecognized taxon might be present. In the latter half of the twentieth century, botanists and ecologists have informally considered the small, upland cane as "hill cane" and have been unconvinced that it could be assigned to either *A. gigantea* or *A. tecta*. Hill cane is often common in mesic and submesic slopes and upland woodlands. Moreover, because of overlapping morphological characteristics, floristic descriptions of *A. tecta* and *A. gigantea* may be confounded by this distinct form of cane. For example, *Arundinaria tecta* has been described as occurring along river branches 450 to 580 feet above sea-level on the southeast slopes and along the courses of mountain streams and shady mesic hillsides in the foothill region, well back from water (Harper 1928; Peattie 1929), but these inland and upland habitats almost certainly are populated by hill cane, not switch cane. In our field work on *Arundinaria*, we located several widespread populations of hill cane along the southern Appalachian Mountain chain, extending the range of the form that Beadle described. Field work has been complemented by herbarium studies to produce our current understanding of the range for this entity.

Species limits within *Arundinaria s.s.* have not been examined previously in a phylogenetic framework or with molecular tools. Our investigation of hill cane is part of a larger study of the phylogenetic history of the North Temperate bamboo clade (in collaboration with the Bamboo Phylogeny Group), and as part of that study we are reconstructing the phylogeny of river cane, switch cane, and hill cane utilizing Amplified Fragment Length Polymorphism (AFLP) data to test the monophyly of putative species and to correlate the results with morphological and geographical characters, with the goal of producing a revised treatment of the genus. Ordination analyses (PCA) of morphological characters and AFLP studies will be presented in a later publication.

Preliminary cladistic analysis of AFLP data (Triplett & Clark, in prep.) demonstrated that the three types of cane form separate monophyletic lineages encompassing two previously recognized entities (river cane and switch cane) and one entity encompassing those plants recognized as hill cane. Moreover, hill cane specimens from a wide geographic range cluster as the sister clade of *A. tecta*, rejecting the hypothesis that hill cane is an ecologically induced form of *A. tecta* and instead suggesting that it is a distinct lineage with a unique evolutionary history. These results prompted a reevaluation of diagnostic characters within *Arundinaria s.s.* Preliminary ordination (PCA) analyses of morphological characters similarly identified three non-overlapping entities and allowed us to recognize the most important diagnostic vegetative features. These groups correspond precisely with the three lineages derived from the AFLP data. We therefore propose the recognition of each entity at the species level: *A. gigantea* (river cane), *A. tecta* (switch cane) and a previously undescribed species (hill cane). In advance of the publication of the Flora of North America, we here describe and illustrate the new species, *A. appalachiana* Triplett, Weakley, &

L.G. Clark, from the southern Appalachian Mountains, and compare and contrast it with its congeners *A. gigantea* and *A. tecta*.

MATERIALS AND METHODS

Field studies of natural populations were conducted in October 2003 and July–October 2005. Standard bamboo collection procedures were followed (Soderstrom & Young 1983); bulky specimens of rhizomes, branch complements, and culm nodes and internodes were made for all collections.

Herbarium specimens from A, F, GA, GH, ISC, NCU, and US (herbarium acronyms following Holmgren & Holmgren 2006) were examined. While our taxonomic circumscription of *Arundinaria* s.s. is based on an approach combining morphological and molecular data, we have relied upon morphological characters to provide identifications of the specimens examined. Complete specimens, including culm leaves, buds, branch complements with foliage leaves, and synflorescences were rarely available, and some herbarium specimens of *Arundinaria* could not be conclusively assigned to species. Only one flowering specimen was located among the specimens identified as *A. appalachiana*.

Specimens were measured for a variety of morphological characters, including foliage leaf length and width, inner ligule length, inflorescence length, spikelet length, and lengths of spikelet bracts (glumes I–IV, lemma and palea). Top knot (the cluster of leaves at the tip of new shoots) and foliage leaf lengths were measured from the base of the pseudopetiole to the tip of the blade. Leaf width was measured at the widest point. Primary branch length was measured from the point of origin at the node to the end of the branch axis. Synflorescence length was measured from the base of the basalmost branch to the apex of the main axis. Spikelets were removed from specimens and softened using a modified Pohl's solution (Pohl 1965; 750 ml distilled water, 250 ml 1-propanol, 2 ml liquid dish soap), dissected, examined, and measured for floral characters using a dissecting microscope equipped with a micrometer. Anatomical characters of leaf blades (both epidermal micromorphology and cross sections) were obtained using light microscopy of sections made following standard protocols for free hand sectioning and epidermal peels (Clark 1986; Ellis 1976, 1979).

RESULTS AND DISCUSSION

Our decision to recognize this taxon at the species level is based upon the combination of phylogenetic and morphologic analyses with careful consideration of the decisions made in the past regarding the North American *Arundinaria* species complex and the ability to diagnose monophyletic units. This interpretation follows from morphological (i.e., diagnostic characters) and phylogenetic (i.e., unique ancestry) species concepts (Olmstead 1995; Sites & Marshall 2003). The features discussed below are those identified as the most diagnostic based

on observations made during field work and morphological ordination analyses (PCA). The most consistent differences among the North American species are seen in vegetative characters including features of the rhizomes, culm internodes and culm leaves, branching, and top knot and foliage blades, described below and summarized in Table 1.

Distribution & ecology

Arundinaria appalachiana is indigenous to the southern Appalachian Mountains where it occurs in the southern Blue Ridge, Blue Ridge/Piedmont Escarpment, upper Piedmont, and Ridge and Valley physiographic provinces (Fig. 1). The full extent of its distribution is still poorly known, because of the infrequent collection of bamboos in eastern North America and the often poor quality of the existing specimens; for this reason we have chosen to supplement vouchered specimens with additional county records based on what we consider reliable sight records of this new species (these counties should be verified with vouchers). Hill cane is common in oak-hickory forests and woodlands on mesic, submesic, and xeric slopes and uplands, sometimes occurring as well in hillside seepages, but nearly always on slopes, bluffs, and ridges away from perennial streams, in contrast to the geographically sympatric *A. gigantea*. Associated overstory species include *Quercus montana* Willd., *Q. coccinea* Münchh., *Q. alba* L., *Q. rubra* L., *Q. falcata* Michx., *Pinus echinata* Mill., *P. virginiana* Mill., *Carya alba* (L.) K. Koch, *Carya glabra* (Mill.) Sweet, and *Nyssa sylvatica* Marshall. Although these slope and ridge forests are well-drained, the annual rainfall amounts in this region are high and equably distributed. In the escarpment gorges of the Chattooga River, Whitewater River, Thompson River, Horsepasture River, Toxaway River, Horsepasture River, and Eastatoe Creek, the highest annual rainfalls in eastern North America (exceeding 80 inches a year) maintain higher then expected moisture levels even in topographic situations that tend to create xeric communities (ridgetops and convex upper slopes and side ridges) (Robinson 2000). Still, there is no question that hill cane occupies unusually dry and upland habitats compared to its congeners. *Arundinaria gigantea* typically occurs on the floodplains of large to small rivers, sometimes edging onto lower portions of mesic slopes, whereas *A. tecta* typically occurs along small to medium blackwater rivers, in swamps, on deep peat in pocosins, and in small seepages with organic soils.

Arundinaria appalachiana is sympatric (at least in the broadest sense) with both of its congeners, in that it occurs in the same counties and within a few kilometers of populations of both *A. gigantea* and *A. tecta*. Within the region occupied by *A. appalachiana* however, *A. gigantea* occurs only along the upper reaches of major rivers, notably the Little Tennessee and French Broad Rivers, while *A. tecta* also occurs at lower elevations and in different topographic and ecological situations.

TABLE 1. Morphological comparisons of *Arundinaria appalachiana*, *A. tecta*, and *A. gigantea*.

Character	A. appalachiana	A. tecta	A. gigantea
Rhizome air canals	present or absent	present	absent
Sulcus	usually absent	usually absent	usually present
Culm leaf duration	persistent	persistent	deciduous
Culm leaf auricles	absent	present, deciduous	present, deciduous
Top knot number of leaves	6–12	9–12	6–8
Top knot leaf blade length (cm)	9–22.5	20–30	16–24
Compressed basal internodes on primary branch	2–5	2–4	0–1
1° branch basal nodes: 2° branches	absent	present, subequal	present, subequal
Primary branch length (cm)	7–33	usually >50	15–25
Foliage leaf blade length (cm)	5–20	7–23	8–15
Foliage leaf blade width (cm)	0.8–2	1–2	0.8–1.3
Foliage leaf vestiture	pilose or glabrous	densely pubescent or glabrous	densely pubescent or glabrous
Foliage leaf duration	deciduous	evergreen	evergreen
Foliage leaf texture	chartaceous	coriaceous	subcoriaceous
Foliage leaf abaxial tessellation	weakly tessellate	strongly tessellate	strongly tessellate

The species biology of *A. appalachiana* is poorly understood. Its congeners are long-lived monocarpic perennials, and this appears to be the case with *A. appalachiana* as well. It has been seen flowering and fruiting even more infrequently than its congeners; judging from its habitat, its flowering and fruiting may be stimulated by fire (like *A. tecta*), and the paucity of fertile specimens may reflect the general suppression of fire in its habitat through the twentieth century. Field observations suggest that clones of *A. appalachiana* are slow-growing and very long-lived, certainly persisting for decades and likely for centuries.

Morphology

Rhizomes.—The rhizomes of *A. appalachiana* are leptomorphic, a characteristic they share with other north temperate woody bamboos; however, in many cases the growing tips of new rhizomes travel only a short distance before turning up to form a new culm, thus presenting a sympodial branching pattern. This pattern also occurs in *A. tecta* but has not been confirmed for *A. gigantea*. An interesting characteristic of this species is the variability in air canal development (McClure 1963). Air canals are present in some specimens but not others, and may in fact be longitudinally and peripherally discontinuous in rhizomes of *A. appalachiana*. Air canals are consistently present in *A. tecta* and are apparently continuous.

Culm internodes.—Although the culm internodes of *A. appalachiana* can

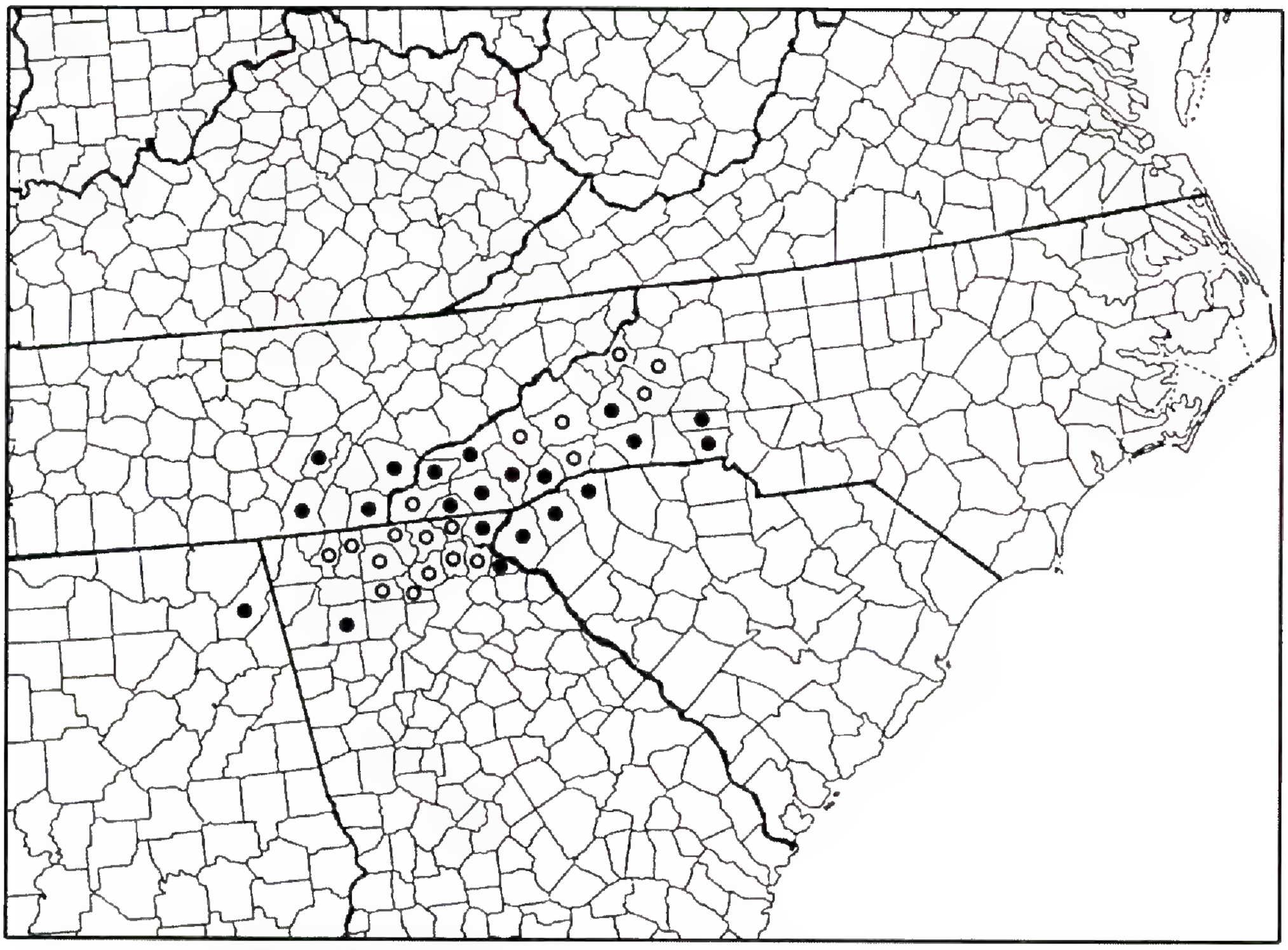


FIG. 1. Distribution of *Arundinaria appalachiana* in the southeastern United States. Filled circles based on documented specimens; open circles based on unvouchered sight records.

be somewhat flattened behind the branch complement, the internodes lack a prominent groove or sulcus. This is consistent with *A. tecta* but contrasts with *A. gigantea*, which typically has internodes that are prominently sulcate.

Branching.—In bamboos, the morphology and architecture of the set of branches arising from culm nodes (the branch complement) is a source of numerous taxonomically useful characters. In *Arundinaria*, the pattern of shortened or compressed internodes at the base of primary branches and the extent and pattern of secondary branching are especially valuable. The branch complement of *A. appalachiana* is characterized by 2–5 shortened or compressed internodes at the base of the primary branch, without rebranching in this basal area. The first elongated internode above the shortened ones is typically constrained to ~30% the length of distal internodes. In contrast, *A. tecta*, while having a similar pattern of compressed internodes, typically will produce buds and branches from the nodes in the area of compression, creating subequal branches from the base of the primary branch. *Arundinaria gigantea* typically has only one (or no) compressed basal internode, but if present, this node may produce a secondary branch. Primary branches in *A. appalachiana* are usually

less than 35 cm long. In contrast, *A. tecta* produces long primary branches usually >50 cm.

Culm leaves.—The culm leaves of *A. appalachiana* are typically shorter than their associated internodes at the base of the plant, becoming progressively longer towards the top knot. At midculm they are approximately the same length as the associated internode. In contrast, midculm culm leaves of *A. tecta* are longer than their associated internodes, and those of *A. gigantea* shorter. *Arundinaria appalachiana* and *A. tecta* have persistent culm leaf sheaths, whereas *A. gigantea* has deciduous sheaths. The culm leaf sheaths of *A. appalachiana* are tessellate; however, their tessellation is not as pronounced as it is in *A. tecta*. The culm leaves lack well-developed, prominent auricles, unlike *A. gigantea* and *A. tecta*.

Top knot and foliage leaves.—In *Arundinaria*, leaves at the tip of new culms are crowded into a distinctive fan-shaped cluster or top knot, with their blades expanded as on foliage leaves. The top knot leaf blades of *A. appalachiana* are typically 9–22.5 cm in length, while *A. tecta* typically has larger blades (20–30 cm long); those of *A. gigantea* are typically 16–24 cm in length. The foliage leaf blades of *A. appalachiana* are deciduous; bladeless branches persist on the plants after leaf drop, often with the older sheaths still intact. The blades are chartaceous; presumably, since the blades are deciduous, the plant invests less energy in producing them by producing less sclerenchyma. In contrast, the leaves of *A. gigantea* are persistent and subcoriaceous, while leaves of *A. tecta* are persistent and coriaceous. The abaxial surfaces of the leaf blades of *A. appalachiana* are weakly tessellate, whereas in *A. gigantea* and *A. tecta* they are strongly tessellate. The abaxial and adaxial leaf surfaces are typically sparsely to more or less densely pilose (glabrous in some populations) in *A. appalachiana*. Leaf blades of *A. gigantea* are typically densely pubescent with short, soft hairs on abaxial surfaces, while the blades of *A. tecta* are densely pubescent on both surfaces; neither of these pubescence patterns has been seen in *A. appalachiana*.

It is important to note that *Arundinaria gigantea* and *Arundinaria tecta* can both survive in deeper shade in the forest, albeit in stunted conditions, and thus it is possible to find diminutive or depauperate plants of both that superficially resemble hill cane, mostly in stature. However, a combination of characters such as the branch complement, leaf texture, and leaf pubescence are usually sufficient to distinguish these stunted forms of river and switch cane from hill cane populations and from each other.

TAXONOMIC TREATMENT

KEY TO THE SPECIES OF *ARUNDINARIA* SENSU STRICTO

1. Primary branches with 0–1 compressed basal internodes; culm internodes usually sulcate; culm leaves deciduous _____ **A. gigantea**

1. Primary branches with 2–5 compressed basal internodes; culm internodes usually terete; culm leaves persistent to tardily deciduous.
   2. Foliage blades coriaceous, persistent, abaxial surfaces densely pubescent or glabrous, strongly tessellate; primary branches usually more than 50 cm long, basal nodes developing secondary branches; top knot blades 20–30 cm long _____ **A. tecta**
   2. Foliage blades chartaceous, deciduous, abaxial surfaces pilose or glabrous, weakly tessellate; primary branches usually less than 35 cm long, basal nodes not developing secondary branches; top knot blades 9–22.5 cm long _____ **A. appalachiana**

Arundinaria appalachiana Triplett, Weakley & L.G. Clark, sp. nov. (**Figs. 1–5**).

TYPE: UNITED STATES. ALABAMA: Dekalb Co.: Desoto State Park by Rt. 89 (34° 30' N Lat.; 85° 38' W Long.), elev. ca. 515 m, 25 Jul 2005, *Triplett & Ozaki 99* (HOLOTYPE: ISC; ISOTYPES: MO, NCU, UNA, US).

Rhizomata leptomorpha, strato cavernularum aëriarum interdum praesenti. Culmi 2–6 mm diametro, 0.5–1.8 m alti, omnino glabri, erecti. Internodia 4.5–12 cm longa, teretia (sine sulco). Vaginae culmorum 5.5–11(–15) cm longae, persistentes, sine auriculis. Culmi juniores fasciculo terminali (5–)6–12 foliorum, laminis (5–)9–22.5 cm longibus, 1.4–2.8 cm latibus, linearibus vel lineari-lanceolatis vel ovati-lanceolatis, pilosis vel interdum glabris. Rami primarii ad nodos medianos culmorum 1, 7–33 cm longi, internodiis abbreviatis sine gemmis basi 2–5. Folia cujusquisque complementi 3–7. Laminae foliorum (3–)5–20 cm longae, 0.5–2 cm latae, chartaceae, deciduae, pilosae vel interdum glabrae, abaxialiter infirme tessellatae. Synflorescentiae 7–11.5 cm longae, 2–5 cm latae, determinatae racemosae apertae; pedicelli 4–25 mm longi, spiculis 6–8. Spiculae 3–5.5 cm longae, glumis 1(–2), flosculis basilibus interdum sterilibus, 5–8 flosculis fertilibus continentibus et anthoeciis rudimentalibus terminalibus 1–3; glumae inaequales, 5-nervatae, attenuatae, glabrae; gluma I 3–6.5 mm longa; gluma II 5.5–9 mm longa; lemmata fertilia 11–16 mm longae, 7–11-nervata, apicibus acutis vel acuminatis, abaxialiter glabris; palea 10–13 mm longa, 8–10-nervata. Stamina 3; anthera 5–7 mm longa.

Woody bamboo. Plants of diffuse to (pluri-) caespitose habit. **Rhizomes** leptomorphic, usually horizontal for a only short distance before turning up at the apex to form a culm (therefore often presenting a sympodial branching pattern), hollow (with a small central lumen), peripheral air canals sometimes present (if so, apparently discontinuous longitudinally and/or peripherally). **Culms** 2–6 mm in diameter, 0.4–1.8 m tall, erect, tillering; **internodes** 4.5–12 cm long (progressively shorter towards culm apex), terete, hollow, glabrous, flattened behind the branch complement on larger culms but the sulcus not prominent; **nodes** solitary, the nodal line horizontal, supranodal ridge not prominent; bud one per node (single) on a slight promontory, triangular, the shoulders of the prophyll ciliate. **Culm leaves** persistent, approximately equaling associated internodes at midculm, typically shorter than associated internodes at the culm base, becoming proportionally longer towards the culm apex; **sheaths** 5.5–11 (–15) cm long, shortest on lower nodes, becoming progressively longer towards the culm apex, glabrous, margins ciliate; **blades** 0.5–1.4 cm long, triangular to lanceolate, reflexed to erect, glabrous, deciduous, intergrading into top knot leaves; **auricles** absent; **fimbriae** 1–9 mm long, ascending to erect; **inner ligules** ca. 0.1 mm long, a fringe of short cilia; **outer ligule** absent. **Top knot leaves** in an apical cluster of (5–)6–12; **sheaths** glabrous, margins ciliate; **auricles** absent; **fim-**



FIG. 2. *Arundinaria appalachiana*. **A.** Top knot of new shoot. **B.** Foliage leaf complement from midculm node. **C.** Foliage leaf, showing apex of sheath, fimbriae, pseudopetiole, and base of blade. **D.** Detail of abaxial surface of blade showing tessellation and pilose vestiture. **E.** Culm leaf at midculm node. **F.** Branch complement showing compressed basal internodes and reiterative secondary branch (arrow). Scale bar = 1 cm unless otherwise noted. All drawings based on *Triplett & Ozaki 99*. (Illustrations by J. Triplett)



FIG. 3. *Arundinaria appalachiana*. **A.** Partially dissected spikelet showing two florets. **B.** Synflorescence with five spikelets. Scale bar = 1 cm. Drawings based on *Ahles & Leisner 15147*. (Illustrations by J. Triplett)

briae 1–9 mm, ascending to erect; **blades** (5–)9–22.5 cm long, 1.4–2.8 cm wide, L:W = 8.3–9.3, linear, linear-lanceolate or ovate-lanceolate, chartaceous, pilose or glabrous, abaxially weakly tessellate, apices acuminate, bases attenuate to cuneate, midrib ± centric. **Branching** infravaginal (rarely extravaginal); **primary branches** 1 per node, 7–33 cm long, with 2–5 compressed basal internodes, basal nodes not developing secondary branches; first elongated internode shorter than subsequent ones (~30%); **higher order branches** present on older plants, reiterating the 1° branch (i.e., with the same pattern of compressed basal internodes and branching). **Foliage leaves** 3–7 per complement; **sheaths** glabrous, margins ciliate, weakly tessellate; **auricles** absent; **fimbriae** 1–9 mm, ascending to erect; **inner ligule** glabrous or ciliate, fimbriate or lacerate; **outer ligule** present as a minute rim; **blades** linear, linear-lanceolate, or ovate-lanceolate, chartaceous, deciduous, surfaces pilose (sometimes glabrous), abaxially weakly tessellate, apices acuminate, bases attenuate to cuneate, midrib ± centric; primary branch foliage leaf blades (4–)9–20 cm long, (0.5–)0.8–2 cm wide; L:W = 10.7–11.7; higher order branch foliage leaf blades (3–)5–17.5 cm long, (0.5–)0.8–1.5 cm wide; terminal foliage leaf blade rarely unexpanded laterally, withering but persisting as a tail-like appendage. **Synflorescences** 7–11.5 cm long, 2–5 cm wide, determi-





FIGS. 4–5. *Arundinaria appalachiana*. **4.** Habit, in Rhea Co., Tennessee. **5.** Close-up of primary branch with compressed basal internodes, Dekalb Co., Alabama. (Photos by J. Triplett)

nate, open-racemose, apparently borne on specialized nonleafy shoots; peduncle 10–17 cm long (3 measured), glabrous, terete; rachis glabrous; pedicels 4–25 mm long; 6–8 spikelets per synflorescence. **Spikelets** 3–5.5 cm long, laterally compressed, disarticulating above the glumes and between the florets, consisting of 1(–2) glumes, occasionally a basal sterile floret, 5–8 fertile florets and 1–3 progressively rudimentary apical sterile florets; **rachilla internodes** 3–4 mm long; **glumes** unequal, 5-nerved, attenuate, glabrous; glume I 3–6.5 mm long; glume II 5.5–9 mm long; **fertile lemmas** 11–16 mm long, 7–11-nerved, apex acute or acuminate, abaxially glabrous, transverse veinlets barely perceptible or not at all manifest, usually somewhat reddish-purple; **paleas** 10–13 mm long, 8–10-nerved, broadly sulcate and 2-keeled dorsally; **lodicules** and **ovary** not seen. **Stamens** 3; anthers 5–7 mm long. **Fruit** not seen.

Distribution and Ecology.—(Fig. 1). Endemic to the southern Appalachians and upper Piedmont of northeastern Alabama, northern Georgia, southwestern North Carolina, northwestern South Carolina, and southeastern Tennessee, United States; 300–800(–1065) m. In upland oak-hickory-pine forests on slopes, less typically in more mesic sites, seeps, or along small streams.

Phenology.—Lack of specimens in flower or information on the extent of

blooming makes it impossible to determine flowering behavior in this species at present. Of the specimens cited below, only one confirmed flowering specimen of this species was identified, suggesting that flowering may be an even rarer event in this species than in most woody bamboos.

Etymology.—*Arundinaria appalachiana* is named for its distribution in the forests of the Appalachian Mountains.

Common name.—hill cane.

Representative specimens examined: **UNITED STATES. ALABAMA. Dekalb Co.:** Little River Canyon National Preserve, plot PIEC 27, 2002, *McDaniel s.n.* (NCU); in steep wooded bank of West Fork, Little River, across stream from overlook shelter, DeSoto State Park, 9 May 1959, *Sherman & Carter 25747* (GH); Desoto State Park on trail by Laurel Creek (34° 30' N Lat; 85° 38' W Long.), elev. ca. 515 m, 25 Jul 2005, *Triplett & Ozaki 100* (ISC, MO, US). **GEORGIA. Bartow Co.:** in woods on S side of Stamp Creek Rd. just E of Jones Mill Rd. (34° 14' N Lat; 84° 40' W Long.), elev. ca. 311 m, 26 Sep 2005, *Triplett 166* (ISC, MO, US). **Rabun Co.:** maple-birch-magnolia association, Laurel Creek Olivine Deposit, 1.5 mi E of Pine Mt., 21 Jun 1946, *Radford s.n* (NCU); oak-hickory woods on Pine Mt., Bald Rd., 4 Jun 1952, *Radford 6134* (NCU); Warwoman Road and Overflow Creek bridge, N side, 20 May 1996, *Stancil 950* (GA); in swamp near top of Oakey Mountain, SE of Nacoochee Reservoir, 25 May 1941, *Duncan 3283* (GA); on trail from 155 0.5 mi S of Kattie Place, elev. ca. 790 m, 22 Oct 1995, *Milsted & Zhang 585* (GA); pine-oak woodland near roadside park, 1 mi N of Tallulah Falls River, 9 May 1967, *Isely, Welsh, & Isely 10286* (ISC); 2 mi N of Warwoman Rd. along GA 28, scattered throughout mature woods W of road (34° 57' N Lat; 83° 10' W Long.), elev. ca. 687 m, 25 Oct 2003, *Triplett & Clark 20* (ISC, MO, US). **Stephens Co.:** Deep gorge, Cedar Creek, Camp Mikell Rd. off GA 184, just W of Camp Mikell and N of Toccoa (34 08' 06" N. lat.; 83 20' 13" W. long), elev. ca. 300 m, 19 Jun 1975, *Boufford & Wood 16501* (NCU); NW-facing ravines and ridges on the S side of Panther Creek, SW of Yonah Lake (Tugaloo River), N of Toccoa (34 43' 30" N. lat.; 83 21' 13" W. long.), 25 Jun 1975, *Boufford & Wood 16766* (NCU). **NORTH CAROLINA. Clay Co.:** Oak-hickory woods, 4 mi NW of Hayesville, 5 Jun 1952, *Radford & Wood 6162* (NCU). **Gaston Co.:** low woodland near the northern tip of Pasour Mt., about 3 mi SSW of High Shoals, 21 Jun 1956, *Ahles & Leisner 15147* (NCU); oak-hickory woods on Crowder's Mt., 4 Jun 1953, *Radford 7084* (NCU). **Graham Co.:** small population on N side of Santeetlah Dam Rd. (SR 1146) just off Hwy 129 (35° 22 N Lat; 83° 51' W Long.), elev. ca. 537 m, 2 Oct 2005, *Triplett 185* (ISC, MO, US). **Jackson Co.:** on highway between Dillsboro & Park Entrance, extensive clump on the top of bank by roadside, 26 Jul 1937, *Coker s.n.* (NCU); Cope Creek Rd. just off NC 23 out of Sylva, growing among *Polytrichum* sp., Pine, and sedge (35° 23' N Lat; 83° 11' W Long.), elev. ca. 675 m, 25 Oct 2003, *Triplett & Clark 21* (ISC, MO, US). **Lincoln Co.:** rich deciduous forest and stream banks 0.4 mi W of Cat Square, 28 Apr 1957, *Bell 6638* (NCU). **Macon Co.:** maple-birch-magnolia (cove) association, Corundum Hill Olivine Deposit, 1 1/2 mi NW Gneiss, 15 Jun 1946, *Radford s.n.* (NCU); Horse Cove near Highlands, 3 Sep 1948, *Radford s.n.* (NCU); in deep, shaded ravine at top of pasture at foot of Whiterock Mountain, 7 mi from Otto, NC on Tessentee Creek Rd., elev. ca. 1065 m, 7 Aug 1938, *Stewart & Hechenbleikner s.n.* (NCU); pine-broom-straw association, Corundum Hill Olivine Deposit, 1.5 mi NW Gneiss, 15 Aug 1946, *Radford s.n.* (NCU); Mulberry Rd. ca. 0.5 mi off 441, on steep hillside among oak, rhododendron, and maple (35° 01' N Lat; 83° 23' W Long.), elev. ca. 647 m, 25 Oct 2003, *Triplett, Clark, & Weakley 19* (ISC, MO, US). **McDowell Co.:** near Marion, 25 Oct 1915, *Ashe s.n.* (NCU). **Polk Co.:** 4 mi W of Tyron, valley of Fall Creek in wet meadow on peninsula in reservoir, 19 Jun 1942, *Walker 3469* (US). **Rutherford Co.:** wet ditch on CR 1721 2 mi N of Sunshine, 24 Jun 1967, *Smith 74* (NCU). **Swain Co.:** Bryson City, by stream, 11 Jul 1927, *Hunnewell s.n.* (GH); Bryson City, private property on W side of Wiggins Rd., 0.3 mi up from Betts Branch (SR 1343) (35° 26' N Lat; 83° 25' W Long.), elev. ca. 601 m, 1 Oct 2005, *Triplett 184* (ISC, MO, US). **Transylvania Co.:** rocks and cliffs on side of mountain, 100 to 200 feet above the bank of Davidson River, Pisgah Forest, 28 Sep 1915, *Ashe s.n.* (NCU); Pisgah Forest, road to

Pink Beds, 23 Aug 1938, *Stewart s.n.* (NCU); Middle Bearcamp Creek area, roadside, Highlands, 2 Aug 1962, *Rodgers & Shake 62165a* (NCU); oak woods near Looking Glass Falls, 7 Jun 1952, *Radford & Wood 6192* (NCU); Horsepasture Gorge, roadside about 1 mi W of crossing, elev. ca. 488 m, 8 Jun 1961, *Rodgers 6162a* (NCU). **SOUTH CAROLINA. Greenville Co.:** Cedar Mountain, 0.4 mi down gravel road 3.8 mi S of Caesar's Head SP Visitor Center (35° 05' N Lat; 82° 36' W Long.), elev. ca. 515 m, 30 Sep 2005, *Triplett 179* (ISC, MO, US). **Oconee Co.:** oak-hickory woods, ridge above Walhalla Fish Hatchery, ca. 11 mi N of junction of S.C. Routes 28 and 107 on Route 107, 9 Jun 1952, *Wood 7879* (A); Hill property, NW side Old Rocky Gap Road, W side West Village Creek near creek, Mountain Rest, Blue Ridge province, elev. ca. 520 m., 24 Aug 1991, *Hill 22585* (GH). **Pickens Co.:** mixed deciduous forest, 3 mi N of Rocky Bottom near US 178, 22 Aug 1956, *Radford 16758* (NCU); Boggs' Rock, granite-gneiss outcrop N of Liberty, 3 Jun 1974, *Knox 407* (NCU); Rich wooded slope, 2.4 mi S of NC line on US 178, 8 Jun 1956, *Ahles & Bell 14298*, (NCU). **TENNESSEE. Hamilton Co.:** Lookout Mt. Nat. Military Park, Chattanooga, 1 small plant at summit of mountain, in hardwood forest., 29 Jun 1957, *Pohl 7664A* (ISC). **Monroe Co.:** White Cliff Springs, Jul 1890, *Lamson-Scribner s.n.* (US). **Polk Co.:** Boyd Gap Overlook above Ocoee River, 4.2 mi W of Hwy 68, on steep wooded hillside just beyond entrance to Boyd Gap Trail #331 (35° 02' N Lat; 84° 27' W Long.), elev. ca. 529 m, 26 Sep 2005, *Triplett 165* (ISC, MO, US). **Rhea Co.:** Firetower Rd just off Hwy 68 next to Grandview Community Center and below intersection with Emergency Road (35° 44' N Lat; 84° 50' W Long.), elev. ca. 445 m, 3 Oct 2005, *Triplett 188* (ISC, MO, US).

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Announcement

The 2006 Applications Delzie Demaree Travel Award

Applications for the 2006 Delzie Demaree Travel Award should include a letter from the applicant telling how symposium attendance will benefit his/her graduate work and letter of recommendation sent by the major professor. Please send letters of application to: Dr. Donna M.E. Ware, P.O. Box 8795, Herbarium, Biology Department, The College of William and Mary, Williamsburg, VA 23185-8795, U.S.A. 1-757-221-2799; Email: ddmware@wm.edu. The period for receiving applications will end three weeks prior to the date of the symposium if a sufficient number of applications are in hand at that time. Anyone wishing to apply after that date should inquire whether applications are still being accepted before applying. The Systematics Symposium dates for 2006 are 13–14 October.

The Delzie Demaree Travel Award was established in 1988 honoring **Delzie Demaree** who attended 35 out of a possible 36 symposia before he died in 1987. Delzie Demaree was a frontier botanist, explorer, discoverer, and teacher. His teaching career as a botanist began in Arkansas at Hendrix College in 1922. He also taught botany at the University of Arkansas, Navajo Indian School, Yale School of Forestry, Arkansas A&M, and Arkansas State University at Jonesboro where in retired as professor emeritus in 1953. One of the things he enjoyed most as a botanist was assisting students with their field botany research.

REVISION OF *BAUHINIA* SUBGENUS *BAUHINIA* SECTION *AMARIA* (CERCIDEAE: CAESALPINIOIDEAE: FABACEAE)

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ABSTRACT

A taxonomic treatment of *Bauhinia* subgenus *Bauhinia* section *Amaria* is presented. Fifteen species are recognized in series *Decandrae* and one species is recognized in series *Stenanthae*. **Bauhinia amatlana** Wunderlin from southern Mexico, **Bauhinia arborea** Wunderlin from Ecuador, **Bauhinia ayabacensis** Wunderlin from Ecuador and Peru, and **Bauhinia geniculata** Wunderlin from Colombia are described and the combination **Bauhinia petiolata** (DC.) Triana ex Hooker f. var. **caudigera** (S.F. Blake) Wunderlin is proposed. Keys, descriptions, and distribution data are provided.

RESUMEN

Se presenta un tratamiento taxonómico de *Bauhinia* subgénero *Bauhinia* sección *Amaria*. Se reconocen quince especies en la serie *Decandrae* y una en la serie *Stenanthae*. Se describen **Bauhinia amatlana** Wunderlin del Sur de México, **Bauhinia arborea** Wunderlin de Ecuador, **Bauhinia ayabacensis** Wunderlin de Ecuador y Perú, y **Bauhinia geniculata** Wunderlin de Colombia, y se propone la combinación **Bauhinia petiolata** (DC.) Triana ex Hooker f. var. **caudigera** (S.F. Blake) Wunderlin. Se aportan claves, descripciones, y datos sobre la distribución.

The pantropical genus *Bauhinia* with approximately 300 species consists of four subgenera: *Bauhinia*, *Piliostigma* [=*Elayuna*], *Barklya*, and *Phanera* (Wunderlin et al. 1987). *Bauhinia* subgenus *Bauhinia*, as defined by Wunderlin et al., contains nine sections, of which three (*Bauhinia*, *Pauletia*, and *Amaria*) are New World.

This is the first of several proposed taxonomic treatments of the New World species of *Bauhinia*. Previous regional treatments in the last half-century such as those for Argentina (Fortunato 1986, 1997), Nicaragua (Wunderlin 2001), Panama (Wunderlin 1976), western Mexico (McVaugh 1987), Venezuelan Guayana (Wunderlin 1998), Middle America (Wunderlin 1983), and parts of the genus for Brazil (Vaz 1979; Vaz and Tozzi 2003) will be placed in the larger context of the entire genus for the Americas following Wunderlin et al. (1987).

In the following revision, 16 species are recognized as comprising section *Amaria*. Fifteen of these are in series *Decandrae* and one in series *Stenanthae*. Series *Triandrae*, containing the single species *Bauhinia pansamalana* Donn. Sm. and placed in section *Amaria* by Wunderlin et al. (1987), is here transferred to section *Bauhinia* and combined in series *Remotae* with *B. pinheiroi*

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Wunderlin with which it shares the characters of three fertile stamens and the same pollen type. The pollen sexine of *B. pansamalana* is striate-reticulate and lacks the infratectal processes characteristic of section *Amaria*.

Bauhinia section **Amaria** (S. Mutis ex Caldas) Endl., Gen. Pl. 1318. 1840. *Amaria* S. Mutis ex Caldas, Semanario Nueva Granada 2:25. 1810. TYPE: *Amaria petiolata* S. Mutis ex DC. [=*Bauhinia petiolata* (S. Mutis ex DC.) Triana ex Hook. f.]. Lectotype designated by Britton and Killip (Ann. New York Acad. Sci. 36:164. 1936).

Trees or shrubs; branches lacking infrastipular spines. Leaves unlobed, bilobed, or rarely bifoliolate. Inflorescence terminal or axillary; floral bud ellipsoid to clavate. Hypanthium cupulate or turbinate to short-tubular; calyx spathaceous, sometimes irregularly splitting into several lobes in late anthesis; petals 5, subequal; fertile stamens 10, the inner 5 shorter than the outer 5, or the inner 5 staminodial, the filaments connate at the base or free; pollen spheroidal, inaperturate or 3-colporoidate, the tectum reticulate or rarely striate-reticulate, with blunt spine-like or rarely low tectal processes continuous from the foot layer through the tectum (infratectal) or rarely supratectal; gynophore partly adnate to the abaxial wall of the hypanthium; stigma oblique-capitate. Fruit dehiscent.

KEY TO THE SERIES OF *BAUHINIA* SECTION *AMARIA*

1. Fertile stamens 10; petals spreading ____ I. Series **Decandrae**
1. Fertile stamens 5; petals strongly imbricate, the corolla forming a pseudotube ____ II. Series **Stenanthae**

I. **Bauhinia** series **Decandrae** Wunderlin, K.Larsen & S.S.Larsen, Biol. Skr. 28:14. 1987. TYPE: *Bauhinia petiolata* (S. Mutis ex DC.) Triana ex Hook. f.

KEY TO *BAUHINIA* SPECIES IN SERIES *DECANDRAE*

1. Leaves unlobed (rarely bilobate or bifoliolate in *B. beguinotii*).
   2. Innermost pair of lateral nerves closer to the mid-nerve than to the adjacent lateral nerves ____ **B. beguinotii**
   2. Innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve.
      3. Petals 3.5–4.5 cm long; fruit 21–27 cm long ____ **B. petiolata**
      3. Petals 1–2 cm long; fruit 8–13 cm long.
         4. Leaves 12–30 cm long, 6–13 cm wide; staminal sheath glabrous; gynoecium tomentose; fruit elliptic-oblong, 3.5–4 cm wide ____ **B. arborea**
         4. Leaves 7–11 cm long, 3–5.5 cm wide; staminal sheath pilose; gynoecium glabrous or glandular; fruit linear, 1.5–2.5 cm wide ____ **B. brachycalyx**
1. Leaves bilobate (rarely bifoliolate or unlobed in *B. beguinotii*).
   5. Leaves with the innermost pair of lateral nerves closer to the mid-nerve than to the adjacent lateral nerves ____ **B. beguinotii**
   5. Leaves with the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve.
      6. Calyx prominently 5-winged ____ **B. geniculata**
      6. Calyx not winged or only very slightly winged (*B. amatlana*)

7. Ovary glabrous or glabrate.
   8. Corolla yellow; flowers in fasciculate clusters, often appearing before the leaves; Mexico to Costa Rica _____ **B. cookii**
   8. Corolla other than yellow; flowers in racemes or panicles, appearing well after the leaves; Ecuador or Peru.
      9. Leaves 1–4 cm long, bilobed to ca. 3/4 the blade length; fruit 4–5 cm long; Peru _____ **B. weberbaueri**
      9. Leaves 5–13 cm long, bilobed to ca. 1/2 the blade length; fruit 15–25 cm long; Ecuador.
         10. Corolla white; staminal sheath ca. 1/8 the stamen length _____ **B. seminarioi**
         10. Corolla red; staminal sheath 3/5 the stamen length _____ **B. haughtii**
7. Ovary tomentose or pilose.
   11. Corolla pink, rose, or white with red or pink at the base.
      12. Leaves ovate, 4–10 cm long, 4–7.5 cm wide; corolla white with red or pink at the base; Colombia and Panama _____ **B. picta**
      12. Leaves suborbicular, 3–4 cm long, 3–4 cm wide; corolla deep pink or rose; Ecuador and Peru _____ **B. ayabacensis**
   11. Corolla white.
      13. Inflorescence and the lower surface of the leaves brown-tomentose _____ **B. seleriana**
      13. Inflorescence and the lower surface of the leaves other than brown-tomentose.
         14. Leaf blade 3.5–5.5 cm long; petals 2–2.7 cm long; Peru _____ **B. augusti**
         14. Leaf blade 0.8–3 cm long; petals ca. 1 cm long; Mexico.
            15. Leaf blade 2–3 cm long, bilobed to 1/2 the length _____ **B. andrieuxii**
            15. Leaf blade 0.8–1.5 cm long, bilobed nearly to the base _____ **B. amatlana**

1. Bauhinia amatlana Wunderlin, sp. nov. (**Fig. 1**). TYPE: MEXICO. OAXACA: ca. 1.5 km NE of San Cristobal Amatlán, ca. 80 km S of Oaxaca and 20 km E of (San Andrés) Miahuatlán (ca. 16°19.6'N, 96°22'W), ca. 1,500 m, 8 Jun 2000, *J. Santiago Martínez s.n.* (HOLOTYPE: USF; ISOTYPES: BRIT, F, MO, NY).

A *Bauhinia andrieuxii* Hemsley foliis minoribus bilobis prope basin differt.

Shrub; branches brown-tomentose when young, soon glabrate. Leaves with the blade chartaceous, 5–7-nerved, broadly suborbicular, broader than long, bilobate nearly to the base, 0.8–1.5 cm long, 1.2–2.2 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base truncate to slightly cordate, the apex of the lobes rounded, the upper surface glabrous, the lower surface sparsely subappressed, short-pubescent, the petiole 4–6 mm long, brown-tomentose; stipules ovate-lanceolate, ca. 1 mm long, caducous; adpetiolar intrastipular excrescence enlarged, forming a flattened subulate projection ca. 1 mm long, the others minute. Inflorescence terminal, 1- to 3-flowered, the peduncle or rachis strigose; floral bud linear-lanceolate, 10–12 mm long, strigose, the apex usually with free calyx lobes

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FIG. 1. *Bauhinia amatlana* (holotype, USF).

to 0.5 mm long, sometimes slightly winged and contorted, the pedicel 5–7 mm long; bract and bracteoles lanceolate, ca. 0.5 mm long. Hypanthium turbinate, 1–1.5 mm long; calyx spathaceous at anthesis; petals white, 10–12 mm long, slightly spreading, short-clawed, glabrous, the blade broadly elliptic, 5–6 mm wide, the margin entire or slightly crisped, the claw 1–2 mm long; fertile stamens 10, the outer five 7–8 mm long, the inner ones slightly shorter, the filaments short-connate at the base, forming a staminal sheath with laciniate projections extending 1–2 mm above the sheath, the sheath short-pilose on the inner surface, glabrous or glabrate on the outer, the anthers linear-oblong, 1–2 long, sparsely pilose; gynoecium 5–7 mm long, the gynophore, ovary, and style subequal, brown-tomentose. Fruit not seen.

PARATYPE. **MEXICO. Oaxaca:** ca. 1.5 km NE of San Cristobal Amatlán, ca. 80 km S of Oaxaca and 20 km E of (San Andrés) Miahuatlán (ca. 16°19.6'N, 96°22'W), ca. 1,500 m, 29 Aug 1995, *J. Santiago Martínez s.n.* (USF).

Etymology.—The name is derived from the Spanish name of the village San Cristobal Amatlán, this in turn derived from *Amatla*, the Aztec name for the place of the tree (*Ficus* sp.) from which the bark is used to make paper.

Distribution and ecology.—Mexico (Oaxaca). Known only from the type locality. Deciduous thorn scrub at ca. 1,500 m.

Bauhinia amatlana is closely related to *B. andrieuxii*, also of Oaxaca, but differs by its leaf blade 0.8–1.5 cm long and bilobed nearly to the base (vs. 2–3 cm long and divided only to the middle in *B. andrieuxii*).

2. Bauhinia andrieuxii Hemsley, Diagn. Pl. Nov. Mexic. 48. 1880; Biol. Cent.-Amer., Bot. 1:336. 1880. TYPE: MEXICO. OAXACA: near Oaxaca, Jul 1834 (fl), *G. Andrieux 411* (HOLOTYPE: K; ISOTYPES: F-fragment, G, K, P; photo ex G: F, MO, US).

Shrub or small tree; branches tomentose when young, soon glabrate. Leaves with the blade chartaceous, 7–9-nerved, suborbicular or broader than long, bilobate to 1/2 the length, 2–3 cm long, 2.5–3 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base cordate to rounded, the apex of the lobes rounded, the upper surface glabrous, the lower surface tomentellous, the petiole 5–15 mm long, tomentellous; stipules ovate, ca. 1 mm long, caducous; adpetiolar intrastipular excrescence enlarged, forming a subulate projection ca. 1 mm long, the others minute. Inflorescence terminal, racemose, 3- to 8-flowered, the rachis strigose to tomentellous; floral bud linear-lanceolate, 12–18 mm long, strigose, the apex with free calyx lobes ca. 1.5 mm long, the pedicel ca. 5 mm long; bract and bracteoles lanceolate, ca. 1.5 mm long. Hypanthium cupulate, 2–3 mm long; calyx spathaceous at anthesis; petals white, ca. 1 cm long, slightly spreading, subsessile, glabrous, the blade broadly elliptic, 4–6 mm wide, the apex rounded, the margin entire; fertile stamens 10, the outer five ca. 1 cm long, the inner ones ca. 5 mm long, the filaments unequally connate near the base for 1–3 mm, glabrous, the anthers

linear-oblong, ca. 2 mm long on the longer stamens, ca. 1.5 mm long on the shorter ones, glabrous; gynoecium ca. 1 cm long, the gynophore, ovary, and style subequal, tomentose. Fruit linear, 8–10 cm long, ca. 1.5 cm wide, apiculate with the persistent style, dark brown, tomentose, the gynophore 5–10 mm long; seeds not seen.

Distribution and ecology.—Western Mexico (Morelos, Oaxaca, and Sinaloa). Deciduous thorn scrub at elevations from near sea level to ca. 1,700 m.

Bauhinia andrieuxii is closely related to *B. amatlana*, also of Oaxaca, but differs by its leaf blade 2–3 cm long, bilobed to the middle (vs. 0.8–1.5 cm long, bilobed nearly to the base in *B. amatlana*).

Specimens examined. **MEXICO. Morelos:** Cañón de Lobos, 14 km on Cuernavaca–Yautepec road, *Fryxell 764* (MEXU); Cañón de Lobos, *Vázquez 1776* (MEXU). **Oaxaca:** without precise locality, *Andrieux 371* (G, P); Monte Albán, *Rose & Hough 4590*; Mitla, *Smith* 107 (US); ruins at Monte Albán, *Sousa et al. 6077* (K, MEXU, MO, WIS); 3 km NE of La Ollaga, *Téllez & Magallanes 233* (K). **Sinaloa:** Cerro Llano Redondo, W of Caimanero, *Gentry 7018* (NY).

3. Bauhinia arborea Wunderlin, sp. nov. (**Fig. 2**). TYPE: ECUADOR. NAPO: Añangu, Parque Nacional Yasuní, 260–350 m, 30 May–21 Jun 1982 (fl), *SEF* [*Studies of Ecuadorean Forests*] *8935* (HOLOTYPE: AAU; ISOTYPES: AAU, NY).

A *Bauhinia brachycalyx* Ducke foliis majoribus, fructibus latioribus, staminum vagina glabra, nec non gynoecio tomentoso differt.

Tree to 30 m; branches glabrous. Leaves with the blade coriaceous, (3–)5–7-nerved, elliptic-oblong, unlobed, 12–30 cm long, 6–13 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base rounded to obtuse, the apex abruptly short-caudate, the upper surface glabrous, the lower surface minutely strigulose, slightly lighter in color than the upper surface, the petiole 2–4.5 cm long, glabrous; stipules broadly lanceolate, ca. 1 mm long, caducous; adpetiolar intrastipular excrescence enlarged, forming a laterally flattened, obtuse projection to 1 mm long, the others minute. Inflorescence subterminal, short-racemose, 10- to 18-flowered, the flowers usually paired, the rachis strigose; floral bud elliptic-lanceolate, 1.5–2 cm long, strigose, the apex acute, the pedicel 1–3 mm long; bract and bracteoles triangular-ovate, ca. 1 mm long. Hypanthium short-tubular, 7–10 mm long; calyx spathaceous at anthesis; petals white, 12–15 mm long, slightly spreading, sessile, glabrous, the blade oblanceolate, 5–7 mm wide, the apex obtuse, the margin slightly crisped; fertile stamens 10, the outer five 12–14 mm long, the inner ones slightly shorter, the filaments free to the base or very short-connate, the anthers lanceolate, 4–6 mm long, sparsely short-pilose on the dorsal surface; gynoecium ca. 8 mm long, the gynophore and style ca. 2 mm long, tomentose, the ovary ca. 5 mm long, tomentose. Fruit elliptic-oblong, ca. 13 cm long, 3–4 cm wide, apiculate with the persistent style base, brown, glabrous, the gynophore 5–8 cm long; seeds not seen.



FIG. 2. *Bauhinia arborea* (isotype, NY).

PARATYPES. **ECUADOR. Morona-Santiago:** 15 km N of Taisha (02°32'S, 77°43'W), *Ortega 96* (USF). **Napo:** Reserva Etnica Huaorani, highway and pipeline "Maxus" under construction (00°51'S, 76°26'W), *Aulestia & Andi 938* (MO, USF); Parque Nacional Yasuní, trail toward Río Daymi (00°52'S, 76°5'W), *Cerón 3371* (MO, USF); ca. 30 km NNW of Coca, Río Huashito, *Pennington 10592* (K); Añangu, Parque Nacional Yasuní (00°31–32'S, 76°23'W), *SEF 8762* (AAU), *SEF 8834* (AAU), *SEF 8867* (AAU), *SEF 8922* (AAU), *SEF 10235* (AAU). **Sucumbíos:** Lago Agrio Cantón, Reserva Cuyabeno, Tarapoa-Tipischa, Río Cuyabeno crossing (76°15'W, 00°00'S), *Palacios et al. 8917* (USF).

Etymology.—The name is derived from the tree habit remarkable for its size within section *Amaria* in Ecuador.

Distribution and ecology.—Eastern Ecuador (Napo, Morona-Santiago, and Sucumbíos). Rain forest on well-drained hilly ground at 250–450 m.

The species is most closely related to *B. brachycalyx* but differs by having larger leaves, wider fruits, a glabrous staminal sheath, and a tomentose gynoecium. *Bauhinia arborea* is a tree to 30 m while *B. brachycalyx* is a shrub or small tree to 6 m, rarely to 15 m.

4. Bauhinia augusti Harms, Repert. Spec. Nov. Regni Veg. 18:234. 1922. TYPE: PERU. CAJAMARCA: near the confluence of the Río Chinchipe and Río Marañón, 700–800 m, 1 May 1912 (fl), *A. Weberbauer 6224* (LECTOTYPE: F, here designated to replace destroyed B holotype: ISOLECTOTYPES: F-fragment, G, NY, US; photo ex B: F, MO, NY, US).

Shrub to 2 m; branches pubescent when young, soon becoming glabrate. Leaves with the blade chartaceous, 7–9-nerved, broadly ovate, bilobed to ca. 1/2 the length, 3.5–5.5 cm long, 3–5 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base cordate, the apex of the lobes obtuse, the upper surface glabrous, the lower surface short-pilose, especially on the nerves, the petiole 0.5–1.5 cm long, short-pilose; stipules triangular-lanceolate, ca. 1.5 mm long, caducous; adpetiolar intrastipular excrescence occasionally enlarged, forming a subulate projection to 2 mm long, the others minute. Inflorescence terminal or subterminal and axillary, short-racemose or paniculate, 4- to 12-flowered, the rachis densely short-pilose; floral bud narrowly ellipsoid, slightly arcuate, 2–2.5 cm long, short-pilose, the apex obtuse or acute, the pedicel 0.5–1 cm long; bract and bracteoles triangular-lanceolate, ca. 1 mm long. Hypanthium short-tubular, 4–6 mm long; calyx spathaceous at anthesis; petals white, 2–2.7 cm long, slightly spreading, short-clawed, glabrous, the blade narrowly elliptic-oblanceolate, 0.5–0.7 cm wide, the apex obtuse, the margin slightly crisped, the claw 3–4 mm long; fertile stamens 10, the outer five 3–3.5 cm long, the inner ones slightly shorter, the filaments short-connate at the base, sparsely pilose, especially toward the base, the anthers elliptic-oblong, ca. 5 mm long, glabrous; gynoecium 3–3.5 cm long, the gynophore, ovary, and style subequal, the ovary densely short-pilose, the style and the gynophore sparsely pilose. Fruit not seen.

Distribution and ecology.—Peru (Cajamarca). Known only from the type collection. At 700–800 m.

Bauhinia augusti is related to the new species *B. ayabacensis* of Ecuador and Peru. *Bauhinia augusti* differs by its white corolla and lower leaf surface with erect trichomes in contrast to the pink corolla and lower leaf surface with appressed trichomes of *B. ayabacensis*.

5. Bauhinia ayabacensis Wunderlin, sp. nov. (**Fig. 3**). TYPE: PERU. PIURA: on road to Ayabaca, 18 km above Puente Tandopa (Río Quiroz), 1,700 m, 24 Sep 1964 (fl), *P.C. Hutchinson & J.K. Wright 6689* (HOLOTYPE: F; ISOTYPES: K, MO, NY, P, US).

A *Bauhinia augusti* Harms corolla rosea lata, foliorum lamina inferiori trichomatibus brevibus adpressis obsita differt.

Shrub or small tree to 4 m; branches pubescent when young, soon becoming glabrate. Leaves with the blade chartaceous, 7(–9)-nerved, suborbicular, bilobed to ca. 1/3 the length, 3–4 cm long, 3–4 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base cordate, the apex of the lobes obtuse to rounded, the upper surface glabrous, the lower surface appressed short-puberulent, especially on the nerves, the petiole 1–1.5 cm long, pubescent; stipules triangular-lanceolate, ca. 1.5 mm long, caducous; adpetiolar intrastipular excrescence occasionally enlarged, forming a subulate projection to 2 mm long, the others minute. Inflorescence terminal or subterminal and axillary, short-racemose, 2- to 10-flowered, the rachis brown-tomentose; floral bud narrowly ellipsoid, slightly arcuate, 2–2.5 cm long, brown-tomentose, the apex acute, the pedicel 6–8 mm long; bract and bracteoles triangular-lanceolate, ca. 1 mm long. Hypanthium short-tubular, 4–6 mm long; calyx spathaceous at anthesis; petals deep pink or rose, 2.5–3 cm long, spreading, short-clawed, glabrous, the blade narrowly elliptic-obovate, 1–1.5 cm wide, the apex apiculate, the margins slightly crisped, the claw 3–4 mm long; fertile stamens 10, the outer five 2–2.5 cm long, the inner ones 1–2 cm long, the filaments short-connate at the base, sparsely pilose, the anthers elliptic-oblong, ca. 5 mm long, glabrous; gynoecium 2–2.5 cm long, the gynophore, ovary, and style subequal, the gynophore and ovary tomentose, the style sparsely pilose. Fruit linear-elliptic, ca. 6 cm long, ca. 1.7 cm wide, apiculate with the persistent style base, brown, strigose to glabrate, the gynophore ca. 1 cm long; seeds ovate-reniform, ca. 1 cm long, 7–8 mm wide, the surface dark brown, dull, the funicular aril-lobe scars unequal, 1–3 mm long.

PARATYPES. **ECUADOR. Loja:** 5 km E of Celica on road to El Empalme, *Harling & Andersson 18183* (GB, MO); El Empalme–Celica road, ca. 5 km above El Empalme, *Harling & Andersson 18221* (MO). **PERU. Cajamarca:** on the crossing to San Luis, *Cabanillas & Guevara 509* (F); El Camote, Carretera Chilete–Contumazá, *Sagástegui & López 7636* (F, MO, USF); between Rupe and Contumazá, *Sagástegui et al. 9817* (MO); near San Pablo, *Sagástegui et al. 15380* (F); Caserío de Chilili, *Sánchez 200* (F); between Chilete and Rupe, E of the Chilete–Contumazá highway, *Sánchez 4222* (F).

Etymology.—The name derived from the town of Ayabaca (Province Ayabaca) near the type locality.



FIG. 3. *Bauhinia ayabacensis* (holotype, F).

Distribution and ecology.—Ecuador (Loja) and Peru (Cajamarca and Piura). Dry, open hillsides in scattered brush or seasonal evergreen forest at 1,200–2,400 m.

Bauhinia ayabacensis is closely related to *B. augusti* from which it differs by its wider deep pink- or rose-colored corolla (vs. white in *B. augusti*) and the lower leaf surface with appressed trichomes (vs. short pilose in *B. augusti*). The petals of *B. ayabacensis* are 1–1.5 cm wide, while those of *B. augusti* are 0.5–0.7 cm wide.

6. Bauhinia beguinotii Cufod., Arch. Bot. Sist. 9:192. 1933. TYPE: COSTA RICA. LIMÓN: between Waldeck and Río Barbilla, 40 m, 12 May 1930 (fl), *G. Cufodontis 664* (HOLOTYPE: W, not seen; photo ex W; ISOTYPES: F, MO, US).

Shrub or small tree to 6(–10) m; branches brown-tomentose to -tomentellous when young, soon becoming glabrate. Leaves with the blade chartaceous, 7–9-nerved, oblong-ovate, unlobed or slightly bilobate (deeply bilobate or bifoliolate in var. *gorgonae*), 10–24 cm long, 5–16 cm wide, the innermost pair of lateral nerves closer to the mid-nerve than to the adjacent lateral nerves, the base rounded to truncate, the apex (if the leaf unlobed) or the lobes (if the leaf bilobed or bifoliolate) acuminate to caudate, the upper surface glabrous, the lower surface brown-tomentellous to glabrate, the petiole 1.5–3.5 cm long, glabrate; stipules broadly ovate, 1–1.5 mm long, caducous; adpetiolar intrastipular excrescence occasionally enlarged, forming a subulate projection to 1 mm long, the apex glandular, the others minute. Inflorescence terminal or subterminal and axillary, racemose, 5–10-flowered, the rachis brown-tomentose to -tomentellous; floral bud elliptic-lanceolate, 1.5–2 cm long, brown-tomentose, the apex with minute free calyx lobes, the pedicel 2–5 mm long; bract and bracteoles ovate, ca. 1 mm long. Hypanthium short-tubular, 5–6 mm long; calyx spathaceous at anthesis; petals white, 2.5–3 cm long, spreading, short-clawed, glabrous, the blade oblanceolate, 8–13 mm wide, rounded, the margin entire, the claw 3–5 mm long; fertile stamens 10, the outer five 2–3 cm long, the inner ones shorter, the filaments connate for ca. 1/2 the length of the shorter stamens, sparsely pilose near the base, the anthers triangular at anthesis, ca. 3 mm long on the longer stamens, ca. 2 mm long on the shorter ones, sparsely pilose to glabrate; gynoecium 2–3 cm long, the gynophore, ovary, and style subequal, brown-tomentose. Fruit linear, 12–15 cm long, ca. 2 cm wide, apiculate with the persistent style, brown, minutely strigose to glabrate, the gynophore 1–1.5 cm long; mature seeds not seen.

KEY TO THE VARIETIES OF *BAUHINIA BEGUINOTII*

1. Leaves unlobed or only slightly bilobate; Costa Rica and Panama _____ var. **beguinotii**
1. Leaves deeply bilobate or bifoliolate; Colombia _____ var. **gorgonae**

6a. Bauhinia beguinotii var. **beguinotii**

Distribution and ecology.—Costa Rica (Limón) and Panama (Bocas del Toro, Panamá, and San Blas). Tropical evergreen forest from near sea level to ca. 500 m.

Specimens examined. **COSTA RICA. Limón:** drainage of the Río Estrilla Valley, *Shank & Molina 4466* (F, US). **PANAMA. Bocas del Toro:** Cerro Bracha, NE of the encampment Changuinola 1 of Corriente Grande (IRHE), *Correa et al. 3227* (PMA, USF); SE and NE of the encampment Changuinola 1 of the IRHE, *Correa et al. 3316* (PMA, USF). **Panamá:** 14.8 km N of the Pan-American Highway, *Folsom & Maas 5202* (MO); Cartí road, 7 mi from turnoff at El Llano (9°15'N, 78°50'W), *Hammel 13547* (MO, USF); 10–12 km N of Pan-American Highway, *Mori & Kallunki 2847* (MO); El Llano–Cartí Tupile road, 16 km N of Pan-American Highway at El Llano, *Nee 9362* (MO); ca. 10 km N of Pan-American Highway, *Nee et al. 8881* (MO). **San Blas**: El Llano–Cartí road (09°20'N, 79°0'W), *Hamilton & Stockwell 1089* (MO, USF); El Llano Cartí road, 19.1 km (09°19'N, 78°55'W), *de Nevers 5946* (MO, USF); Nusagandi along continental divide on El Llano Cartí road (09°19'N, 78°15'W), *de Nevers & Perez 3701* (MO, USF); Nusagandi along the continental divide on the El Llano Cartí road (09°19'N, 78°15'W), *de Nevers & Pérez 3582*; Nusagandi, along the continental divide on the El Llano–Cartí road (09°19'N, 78°15'W), *de Nevers & Pérez 3781* (MO, USF); Nusangandi ridge running NW from Punta Mamá, (09°19'N, 78°15'W), *de Nevers et al. 3728* (MO, USF); El Llano–Cartí road, 19.1 km from Interamerican Hwy, (09°19'N, 78°55'W), *de Nevers et al. 4957* (MO, USF); El Llano Cartí road, near Nusagandi, along Sendero Nusagandi, W of buildings (09°15'N, 79°0'W), *McPherson 11033* (MO, USF).

6b. Bauhinia beguinotii var. **gorgonae** (Killip ex R.S. Cowan) Wunderlin, Ann. Missouri Bot. Gard. 60:570. 1973. *Bauhinia gorgonae* Killip ex R.S. Cowan, Bol. Soc. Venez. Ci. Nat. 22:281. 1961. TYPE: COLOMBIA. NARIÑO: E side of Isla Gorgona, 50–100 m, 11 Feb 1939 (fl), *E.P. Killip & H. García-Barriga 33170* (HOLOTYPE: US; ISOTYPES: COL., not seen, BM, US).

Distribution and ecology.—Colombia (Nariño). Tropical evergreen forest from near sea level up to 100 m.

The Colombian material is recognized at the varietal level and is distinquished from the Panamanian and Costa Rican material only in having the leaves deeply bilobate or bifoliolate rather than unlobed or only slightly bilobate. Since the degree of lobing of leaves in *Bauhinia* is often quite variable within species, further collections may prove var. *gorgonae* to be unworthy of recognition.

Specimens examined. **COLOMBIA. Nariño:** Isla Gorgona, *Cheeseman* [St. George Expedition] *380* (F, K, US), *Collenette* [St. George Expedition] *628* (F, K, US), *Kelsall* [St. George Expedition] *360* (K, US).

7. Bauhinia brachycalyx Ducke, Trop. Woods 90:12. 1947. TYPE: BRAZIL. AMAZONAS: region of the Rio Purus near the mouth of the Rio Pauini [based on plant cultivated in the Horto Botánico do Museu Goeldi, Belém, Pará, specimen made 30 Dec 1946 (fl)], *A. Ducke 2045* (HOLOTYPE: MG, not seen; ISOTYPES: NY, US).

Shrub or small tree to 6(–15) m; branches glabrous. Leaves with the blade subcoriaceous, 5-nerved, oblong-ovate, unlobed, 7–11 cm long, 3–5.5 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base rounded to subtruncate, the apex with a caudate tip 1–2 cm long, the upper surface glabrous, the lower surface glabrous,

the petiole 0.8–1.4 cm long, glabrous; stipules ovate, ca. 1 mm long, caducous; adpetiolar intrastipular excrescence often enlarged, forming a subulate projection to 2 mm long, the others minute. Inflorescence terminal or subterminal and axillary, short-racemose, 6- to 12-flowered, the flowers usually paired, the rachis minutely puberulent; floral bud elliptic-oblanceolate, ca. 1.5 cm long, minutely puberulent, the apex apiculate, the pedicel 3–4 mm long; bract and bracteoles ovate-lanceolate, ca. 1 mm long. Hypanthium short-tubular, 4–6 mm long; calyx spathaceous at anthesis; petals white, ca. 1.5(–2) cm long, slightly spreading, subsessile, glabrous, the blade linear-oblanceolate, 4–5 mm wide, the apex acute, the margins slightly crisped; fertile stamens 10, the outer five 8–10 mm long, the inner ones ca. 1/2 as long, the filaments short-connate at the base, forming a staminal sheath with a laciniate projection extending 1–2 mm above the sheath, the sheath tomentose on the inner surface, glabrous on the outer, the anthers linear-oblong, ca. 3 mm long, sparsely pilose at the apex and the base; gynoecium 12–15 mm long, subequaling the androecium, arcuate, the ovary 5–6 mm long, the gynophore and the style 3–4 mm long, subequal, the style and the upper portion of the ovary with glandular trichomes in lines, the gynophore glabrous, the stigma oblique. Fruit linear, 10–12 cm long, 1.5–2.5 cm wide, apiculate with the persistent style, brown, glabrous, the gynophore ca. 0.5 mm long; seeds suborbicular, 11–12 mm long, 9–10 mm wide, dark brown, the surface dull, the funicular aril-lobe scars subequal, extending ca. 1/2 way around the seed.

Distribution and ecology.—Ecuador (Napo and Sucumbíos), Peru (Amazonas, Loreto, and Pasco), and Brazil (Amazonas). In forest on well drained upland, also often on inundated clay soil and along rivers at 200 m.

Specimens examined. **ECUADOR. Morona-Santiago:** oil well "Garza" of Tenneco, ca. 35 km NE of Montalvo (01°49'S, 76°42'W), *Zak & Espinoza 4618* (MO, USF) **Napo**: road construction on the Yuca Road, ca. 3 km from the Auca oil-field Road (ca. 00°31'S, 76°58'W,) *Brandbyge et al. 30287* (AAU, USF); Parque Nacional Yasuní, oil well "bogi" of Conoco (00°43'S, 76°28W), *Coello 225* (MO, USF); Añangu, N side of Río Napo, trail from village to laguna (00°31'S, 76°23'W), *Lawesson et al. 39571* (AAU, USF); Añangu, near the outlet of Río Añangu into Río Napo in the Parque Nacional Yasuní, *SEF 10133* (AAU); Añangu, near the outlet of Río Añangu into Río Napo in the Parque Nacional Yasuní, *SEF 10389* (AAU) **Sucumbíos:** Río Gueppi, tributary of Río Putumayo, above Peruvian border post of Puerto Perú, 8 km above mouth of river, *Gentry et al. 21805* (MO, USF); Lago Agrio Cantón Reserva Faunística Cuyabeno, Río Lagarto, on border with Peru (00°33'S, 75°16'W), *Palacios et al. 8055* (MO, USF). **PERU. Amazonas:** Yamayakat, Quebrada Kusu-Chapi, Río Marañón (00°55'S, 78°19W), *Vásquez et al. 20104* (MO, USF). **Loreto:** Chambira, near Yurimaguas, Río Huallaga Valley, *Ferreyra 4952* (NY, US); Río Gueppi, tributary of Río Putumayo, northernmost tip of Peru on border with Ecuador, between mouth of River and the border post of Puerto Perú ca. 8 km upriver, *Gentry et al. 21772* (MO, USF); trail from Indiana on Río Amazonas to Río Napo, *Gentry et al. 22188* (MO, USF); Río Nanay on the road to the Marina across from Bellavista, *Rimachi 2800* (MO); San Miguel (Quebrada Tamshiyacu) (04°15'S, 72°40'W), *Vásquez & Jaramillo 7153* (MO, USF); Iquitos Buena Suerte (Río Itaya), *Vásquez & Jaramillo 8418* (MO, USF); Indiana, Yanamono, Río Amazonas (03°30'S, 72°50'W), *Vásquez & Jaramillo 11103* (MO, USF); Indiana, Yanamono, Explorama Lodge (03°28'S, 72°50'W), *Vásquez et al. 12113* (MO, USF). **Pasco:** Palcazú Valley, Iscozacín (10°12'S, 75°15'W), *Foster 9463* (MO, USF). **BRAZIL. Amazonas:** Rio Javari, Miraflor, *Lleras et al. [Prance] P16927* (K, MO, US).

8. Bauhinia cookii Rose in Britton & Rose, N. Amer. Fl. 23:205. 1930. TYPE: COSTA RICA. ALAJUELA: Cuesta de la Vieja, road to San Carlos, 300 m, 11 Apr 1903 (fl), *O.F. Cook & C.B. Doyle 41* (HOLOTYPE: US; ISOTYPES: NY-fragment, US).

Casparia calderonii Rose in Britton & Rose, N. Amer. Fl. 23:217. 1930. *Bauhinia calderonii* (Rose) Lundell, Phytologia 1:214. 1937. TYPE: EL SALVADOR. SONSONATE: San Julián, 1924 (fr), *S. Calderón 2226* (HOLOTYPE: US; ISOTYPES: NY-fragment, US).

Bauhinia gigas Lundell, Phytologia 1:213. 1937. TYPE: BELIZE. EL CAYO: Valentín, Jun–Jul 1936 (st), *C.L. Lundell 6298* (HOLOTYPE: MICH; ISOTYPES: NY, US).

Tree to 15(–40) m; branches strigose or puberulent when young, soon becoming glabrate. Leaves with the blade submembranaceous or chartaceous, 7–9-nerved, broadly ovate, bilobate to ca. 1/2 the length, 5–10(–15) cm long, 7–10(–12) cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base cordate to truncate, the apex of the lobes acute to obtuse, the upper surface glabrous, the lower surface strigose, at least on the nerves, the petiole 2–3(–5) cm long, slightly strigose; stipules lanceolate, ca. 1.5 mm long, caducous; adpetiolar intrastipular excrescence enlarged, forming a subulate projection to 1.5 mm long, the others minute. Inflorescence paniculate, congested into a fasciculate cluster, sometimes produced before the leaves and appearing cauliflorous or ramiflorous, 15- to 60-flowered, the rachis strigose; floral bud linear-elliptic, 8–10 mm long, strigose, the apex with minute free calyx lobes, the pedicel 5–7 mm long, strigose; bract and bracteoles ovate-lanceolate, ca. 1 mm long. Hypanthium cupulate, 2–3 mm long; calyx spathaceous at anthesis; petals light sulfur-yellow, 10–15 mm long, spreading, sessile or short-clawed, glabrate, the blade elliptic to oblanceolate, 5–7 mm wide, the apex obtuse, the margin entire; fertile stamens 10, the outer five 10–15 mm long, the inner ones 5–10 mm long, the filaments connate at the base for ca. 1 mm, with a laciniate rim projecting above, glabrate, the anthers linear-oblong, ca. 2 mm long on the longer stamens, ca. 1.5 mm long on the shorter ones; gynoecium 5–10 mm long, the gynophore, ovary, and style subequal. Fruit linear, 5–7 cm long, ca. 1.5 cm wide, apiculate with the persistent style, light brown, glabrous, the gynophore 5–10 mm long; seeds obovate, 7–10 mm long, 5–8 mm wide, the surface dull, dark brown, the funicular branch scars equal, ca. 4/5 the length of the seed.

Distribution and ecology.—Western Mexico in Sinaloa southeast through Mexico and Central America to Costa Rica. Not known from Nicaragua, but to be expected there. Tropical deciduous or semideciduous forests at elevations from near sea level to ca. 4,200 m, but more commonly 300–1,000 m. It apparently flowers throughout the year, but usually from March to July. Flowers are sometimes produced before the leaves appear or are much developed.

The species is unusual not only in section *Amaria* by having yellow flowers, but in fact, no other New World species of subgenus *Bauhinia* has flowers of this color.

Specimens examined. **MEXICO. Chiapas:** vicinity of La Chacona, *Miranda 6485* (US). **Colima**: vicinity of Manzanillo, *Ferris 6022* (A, F, US); ca. 15 mi SSW of Colima on Manzanillo road (3 mi above Terolapa), *McVaugh 15541* (MICH); ca. 14 mi WNW of Santiago on road to Cihuatlán, Jalisco, *McVaugh 20776* (G, MICH, US). **Guerrero:** Cañón de la Mano Negra, near Iguala, *Rose et al. 9344* (F, GH, NY, US). **Jalisco:** between Bahía Navidad and La Manzanilla on Bahía Tenacatita, 3 mi W of Autlán–Navidad road, *McVaugh 21007* (MICH); near Playa de Cuastecomate, 8 km by road NW of Navidad, *McVaugh & Koelz 1674* (MICH). **Nayarit:** 7–8 mi W of Compostela along road to Mazatlán, *Gentry & Gilly 10848* (DUKE, MEXU, TEX, WIS); 6–7 mi S of Compostela, *McVaugh 18753* (G, MICH, US). **Oaxaca:** Ejido Benito Juárez, Sebástopol, Tuxtepec, *Dioscorea Brigade 2741* (MEXU). **Sinaloa:** Mazatlán, *Reko 4520* (MEXU, US). **Veracruz:** Barranca de Panoaya, *Purpus 8797* (UC), *Purpus 8896* (GH, MO, NY, UC, US); near Rancho Remundadero, *Purpus 11068* (NY, US), *Purpus 11069* (A), *Purpus 11170* (MO); Municipio Puente Nacional, La Ceiba, *Ventura 12760* (MEXU). **GUATEMALA. Escuintla:** Hacienda Aguna, *Salas 1406* (F); Río Guacalate, *Standley 60187* (F, US). **Guatemala:** without precise locality, *Aquilar 610* (F). **Retalhuleu:** Río Talculán, 5 mi W of Retalhuleu, *Standley 87377* (F). **Suchitepéquez:** along Río Madre Vieja above Patulul, *Standley 62207* (F). **HONDURAS. Comayagua:** Pito Solo, Lake Yojoa, *Edwards P-404* (F, K, US). **EL SALVADOR. Ahuachapán:** Finca San Benito, near Río Guayapa (13°49'N, 89°56'W), *Reyna et al. 1095* (USF); Finca San Benito, along Río Nacimiento del Guayapa (13°51'N, 89°55'W), *Witsberger 600* (USF). **COSTA RICA. Alajuela:** along road between Cañas and Upala, 10 km N of Bijagua, *Croat 36478* (MO, USF); plains of the Río San Carlos, *Pittier 16695* (US). **San José:** Cerro Bijaqualito-Tárcoles, *Poveda 1097* (MO).

9. Bauhinia geniculata Wunderlin, sp. nov. (**Fig. 4**). TYPE: COLOMBIA. RISARALDA: Hacienda Alejandría, 6 km on highway between La Virginia and Cerrito, low hills of the extreme north of the wide part of the Valle del Río Cauca, ca. 940 m, 27 May 1989 (fl), *P.A. Silverstone-Sopkin, J. Giraldo, & M. Cabrera 5270* (HOLOTYPE: CUVC; ISOTYPE: USF).

A *Bauhinia petiolata* (DC.) Triana ex Hooker f. foliis lobatis, calyce alto, nec non androecii forma singulari differt.

Tree to 5 m; branches glabrous. Leaves with the blade coriaceous, 7–9-nerved, oblong-ovate, bilobed to ca. 2/3 the length, 14–26 cm long, 9.5–17 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base shallowly cordate to subtruncate, the apex of the lobes acuminate, the upper surface inconspicuously reticulate, glabrous, the lower surface evidently reticulate, with inconspicuous, colorless, medially attached, biradiate, glandular trichomes, minutely strigose, at least on the veins near the base, the petiole 2–3(–4) cm long, glabrous; stipules triangular-ovate to lanceolate, 1–1.5 mm long, caducous; adpetiolar intrastipular excrescence sometimes enlarged and forming a laterally flattened, blunt projection to 2 mm long, others minute. Inflorescence terminal or subterminal and axillary, racemose, 2- to 10-flowered, the flowers solitary or paired, the rachis reddish brown-tomentose; floral bud linear-clavate, 4–4.5 cm long, sparsely brown-tomentose, evidently 10-nerved, becoming prominently 5-winged above the hypanthium with the wings gradually enlarging toward the apex to 4 mm, the pedicel ca. 1.5 cm long; bract and bracteoles triangular-ovate, ca. 1 mm long. Hypanthium short-tubular, 1.5–2.2 cm long; calyx green, spathaceous at anthesis, each sepal with a thickened nectiferous area ca. 5–7 mm long and wide near the base; petals white, 3.5–4.5 cm long, slightly spreading, subsessile, glabrous,



FIG. 4. *Bauhinia geniculata* (isotype, USF).

the blade oblanceolate, 15–18 mm wide, gradually tapering to the thickened midrib at the base, the apex rounded to slightly emarginate; fertile stamens 10, the outer five 4–4.5 cm long, the inner ones shorter, the filaments connate at the base for 2–3 mm and forming a staminal sheath, the uppermost stamen of the inner whorl the shortest and strongly geniculate near the point of attachment near the apex of the shield-like portion of the staminal sheath, the staminal sheath with a ligulate projection ca. 1 mm long behind the lower 3 stamens of the outer whorl and with a minute projection behind the lower 2 stamens of the inner whorl, the sheath reddish tomentose on the inner surface, the anthers linear, 7–8 mm long, glabrous; gynoecium 3.5–4.5 cm, the gynophore ca. 1.5 cm long, reddish tomentose, the ovary ca. 2 cm long, reddish tomentose, the style ca. 1.5 cm long, reddish tomentellous to glabrate near the apex. Fruit linear, 29–41 cm long, 2.8–3.3 cm wide, apiculate with the persistent style base, brown, puberulent, the gynophore 2.5–4 cm long; seeds suborbicular to oblong, strongly compressed, 17–18 mm long, 12–15 mm wide, the surface dull brown, the funicular scars subequal, extending 2/3 to nearly the length of the seed.

PARATYPE. **COLOMBIA. Risaralda:** Hacienda Alejandría, 6 km on highway between La Virginia and Cerrito, low hills of the extreme north of the wide part of the Valle del Río Cauca, *Silverstone-Sopkin et al. 5809* (CUVC, USF).

Etymology.—The name derived from the bent uppermost stamen of the inner staminal whorl.

Distribution and ecology.—Colombia (Risaralda). Primary forest at 900–940 m.

Bauhinia geniculata is most closely related to *B. petiolata*, but differs by its lobed leaves (vs. unlobed in *B. petiolata*), winged calyx (vs. not winged in *B. petiolata*), and unique androecial morphology.

10. Bauhinia haughtii Wunderlin, Brittonia 35:337. 1983. TYPE: ECUADOR. MANABÍ: Bella Vista, SE of Santa Ana, 100 m, 5 Sep 1942 (fl, fr), *O. Haught 3481* (HOLOTYPE: US; ISOTYPES: K, NY).

Shrub or tree to 10 m; branches glabrous. Leaves with the blade submembranaceous, 9(–11)-nerved, suborbicular, bilobed to ca. 1/2 the length, 5–8 cm long, 6–10 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base deeply cordate, the apex of the lobes obtuse to rounded, the upper surface glabrous, the lower surface minutely strigose, the petiole 3–5 cm long, glabrous; stipules triangular-lanceolate, ca. 1 mm long, caducous; intrastipular excrescences minute. Inflorescence terminal or subterminal and axillary, racemose, 6- to 10-flowered, the flowers usually paired, the rachis minutely strigulose-tomentose; floral bud narrowly elliptic, 5–6 cm long, minutely strigulose-tomentose, red, the apex attenuate, the pedicel 2–5 mm long; bract and bracteoles triangular-lanceolate, ca. 1 mm long. Hypanthium tubular, 2–2.5 cm long, slightly arcuate; calyx spathaceous at anthesis; petals red, 4.5–5 cm long, slightly spreading, short-clawed, glabrous, the blade

oblanceolate, 1–1.5 cm wide, the apex rounded, the margin entire, the claw 3–4 mm long; fertile stamens 10, red, the outer five 4.5–5.5 cm long, the inner ones slightly shorter, 9 connate into a staminal tube for ca. 3/5 their length, the other one free to ca. 0.5 cm lower and slightly longer, the staminal sheath sparsely short pilose on the inner surface, the anthers elliptic-oblong, ca. 5 mm long, glabrous; gynoecium 6.5–8.5 cm long, the gynophore, ovary, and style subequal, glabrous. Fruit linear, 16 cm long, 1.7 cm wide, apiculate with the persistent style, light brown, glabrous, the gynophore 4.5 cm long; seeds not seen.

Distribution and ecology.—Ecuador (Manabí and Pichincha). In tropical wet forest at 100–300 m.

Bauhinia haughtii is a distinctive species most closely related to *B. seminarioi*, also endemic to Manabí, Ecuador. It differs from that species by its red flowers (vs. white in *B. seminarioi*) and a much longer staminal sheath (ca. 3.5 cm vs. ca. 6 mm in *B. seminarioi*). The only other red-flowered species in Ecuador, *B. stenantha*, is readily distinguished by its five fertile stamens (vs. ten) and smaller flowers (2.5–3.0 cm long) and smaller fruits (6–10 cm long).

Specimen examined. **ECUADOR. Manabí:** 170–175 km on road between Santa Domingo and Quininde, *Acosta-Solís 13653* (F).

11. Bauhinia petiolata (DC.) Hook. f., Bot. Mag. 103: tab. 6277. 1877. *Amaria petiolata* DC., Prodr. 2: 519. 1825. TYPE: COLOMBIA: without precise locality, 1760–1808, *S. Mutis 2398* (HOLOTYPE: MA, not seen; ISOTYPE: US).

Amaria sessilifolia DC., Prodr. 2:519. 1825. *Bauhinia sessilifolia* (DC.) Quiñones, Ann. Missouri Bot. Gard. 75:1156. 1988. TYPE: COLOMBIA: without precise locality, 1760–1808, *S. Mutis 2724* (HOLOTYPE: MA, not seen; ISOTYPE: US-fragment).

Shrub or tree to 15 m; branches glabrous. Leaves with the blade chartaceous to coriaceous, 5-nerved, ovate, unlobed, 8–14 cm long, 4–8 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base rounded to deeply cordate, the apex acute, sometimes with a caudate tip to 3 cm long, the upper surface glabrous, the lower surface glabrous, often glaucous, conspicuously reticulate-nerved, the petiole 0.5–3.5 cm long, glabrous; stipules triangular, ca. 1 mm long, caducous; adpetiolar intrastipular excrescence often enlarged and forming a blunt subulate projection ca. 1 mm long, the others minute. Inflorescence terminal or subterminal and axillary, short-racemose, 4- to 8-flowered, the rachis sparsely strigose-tomentellous to glabrate; floral bud elliptic-ovate, 2–3 cm long, strigulose-to-mentose, the apex attenuate, glabrous, the pedicel to 1 cm long; bract and bracteoles triangular-ovate, ca. 1 mm long. Hypanthium short-tubular, ca. 1.5 cm long; calyx spathaceous at anthesis; petals white, 3.5–4.5 cm long, slightly spreading, short-clawed, glabrous, the blade narrowly oblanceolate, 1.2–1.5 cm wide, the apex rounded, the margin slightly crisped, the claw 2–3 mm long; fertile stamens 10, the outer five 3–5(–7.5) cm long, the inner ones slightly shorter,

the filaments short-connate at the base, glabrous, the anthers linear-oblong, 8–12 mm long, glabrous; gynoecium 4–5 cm long, the gynophore ca. 1 cm long, glabrous, the ovary ca. 3 cm long, tomentose (glabrous or glabrate in var. *caudigera*), the style ca. 1.5 cm long, glabrous. Fruit linear, 21–27 cm long, 2–2.5 cm wide, apiculate with the persistent style, brown, sparsely pubescent, glabrescent at maturity, the gynophore ca. 2.5 cm long; seeds not seen.

Bauhinia petiolata is a highly distinctive though poorly known species represented by two varieties. The species is most closely related to *B. geniculata* which is also from the upper Magdalena Valley (Risaralda Prov.) in Colombia but is readily distinguished by its unlobed leaves and flower buds not winged. It also has affinities with *B. arborea* (Ecuador) and *B. brachycalyx* (Ecuador, Peru, and Brazil), two other species with unlobed leaves in section *Amaria*.

Quiñones (1988) argues that *B. sessilifolia* is a distinct species and differs from *B. petiolata* by its sessile leaves, the leaf base deeply cordate, the inflorescence of axillary umbels, the petals emarginate, the stamens of five long and five short and included, and the fruit 2 cm wide. *Bauhinia petiolata* on the other hand has leaves with the petiole 0.5–3 cm long, the leaf base truncate or rounded, the inflorescence a terminal or axillary in a short raceme, the petals acute, the stamens subequal and excluded, and the fruit 1.5 cm wide. These characters, with the exception of the sessile leaves, do not hold up in the material examined. Even though I have not seen the MA material cited by Quiñones, I believe that *B. sessilifolia* is based on aberrant, sessile-leaved specimens of *B. petiolata*. The sessile-leaved condition is approached in some material seen for *B. petiolata*. For example, *André 1810* has petioles only 5 mm long.

KEY TO THE VARIETIES OF *BAUHINIA PETIOLATA*

1. Ovary tomentose; central Colombia _____ var. **petiolata**
1. Ovary glabrous or glabrate; Panama and Venezuela _____ var. **caudigera**

11a. **Bauhinia petiolata** var. **petiolata**

Distribution and ecology.—Upper Magdalena Valley of central Colombia (Cundinamarca and Tolima). Wet forest at ca. 500 m.

Specimens examined. **COLOMBIA. Cundinamarca:** Quebrada Cachimbulo near Tocaima, Río Funza valley, *André 1810* (K); Río Magdalena valley, *Goudot s.n.* (P); Hacienda El Cucharo, between Tocaima and Pubenza, *Killip et al. 38314* (COL, F, NY, US), *Killip et al. 38350* (COL, K, US); between Nilo and Puebla Nuevo, *Murillo & Jaramillo 260* (COL, NY); Tocaima, *Triana 4412* (BM, COL, G, NY); La Parada Limba and the Río Magdalena valley, *Triana s.n.* (P); Tocaima, *Triana s.n.* (K); Tocaima, Río Magdalena, *Triana s.n.* (K). **Tolima:** Chicoral, *Haught 6306* (COL, NY, US). **State unknown:** without locality, *Mutis 2377* (fragment ex MA: US); *Mutis 2549* (fragment ex MA: US); *Mutis 4146* (fragment ex MA: US). Cultivated at Kew from material provided by Linden from Colombia (K).

11b. **Bauhinia petiolata** var. **caudigera** (S.F. Blake) Wunderlin, comb. nov. BASIONYM:

Bauhinia caudigera S.F. Blake, Contr. U.S. Natl. Herb. 20:522. 1924. TYPE: VENEZUELA. CARABOBO: Guaremales, along road from Puerto Cabello to San Felipe, 10–100 m, 20 May–10

Jun, 1920 (fl), *H. Pittier 8851* (HOLOTYPE: US; photo ex US: US, NY; ISOTYPE: P).

Distribution and ecology.—Panama (Colón) and Venezuela (Carabobo and Falcón). Rainforest and wet forest at 10–600 m. The variety was probably more widely distributed from Panama through northern Colombia to Venezuela in the past. Its present disjunct distribution is relictual, apparently now confined to wet river valley refugia.

This taxon was placed in synonymy of *B. petiolata* by Wunderlin (1983). Since then, additional material has become available and it is here considered as a distinct variety on the basis of its glabrous or glabrate ovary (vs. tomentose in var. *petiolata*).

Specimens examined. **PANAMA. Colón:** ca. 2–3 mi up the Río Guanche from mouth, *Kennedy & Foster 2127* (MO, USF). **VENEZUELA. Carabobo:** upper Guaremales, road from Puerto Cabello to San Felipe, *Pittier 8914* (NY, US). **Falcón:** Parque Nacional Quebrada de la Cueva El Toro (10°50'N, 69°07'W), *Liesner et al. 7727* (MO, USF), *Liesner et al. 7736* (MO), *Wingfield 7501* (USF).

12. Bauhinia picta (Kunth) DC., Prodr. 2:515. 1825. *Pauletia picta* Kunth, in Humboldt et al., Nov. Gen. Sp. 6:316. 1824. TYPE: COLOMBIA. SANTANDER: along the Río Magdalena near the confluence with Río Opon, between Bojorque and Isla de Brujas, May 1801 (fl), *F.W.H.A. Humboldt & A.J.A. Bonpland 1604* (HOLOTYPE: P, not seen, microfiche IDC 156/C6; ISOTYPES: P, B(W) not seen; photo ex B(W): F, G, MO, NY, US).

Bauhinia ligulata Pittier, Contr. U.S. Natl. Herb. 20:112. 1918. TYPE: PANAMA. SAN BLAS: near Puerto Obaldía, 0–50 m, Aug 1911 (fl), *H. Pittier 4334* (HOLOTYPE: US; ISOTYPES: BM, F, NY, US).

Bauhinia kalbreyeri Harms, Repert. Spec. Nov. Regni Veg. 19:65. 1923. TYPE: COLOMBIA. ANTIOQUIA: Murri, 1,000–1,100 m, Jun 1880 (fl), *W. Kalbreyer 1802* (LECTOTYPE: K, here designated to replace destoyed B holotype; ISOLECTOTYPES: F-fragment, US; photo ex K: F, NY, US; photo ex B: F, K, MO, NY, US).

Tree to 20(–40) m; branches ferruginous-tomentose when young, soon becoming glabrate. Leaves with the blade chartaceous, 9–13-nerved, ovate, bilobate to ca. 1/4 the length, 4–10(–21) cm long, 4–7.5(–15) cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base cordate to rounded, the apex of the lobes apiculate to obtuse or rounded, the upper surface glabrous, the lower surface finely ferruginous-tomentellous (at least on the nerves), the petiole 2–3.5 cm long, ferruginous-tomentellous to glabrate; stipules ovate, ca. 1 mm long, caducous; adpetiolar intrastipular excrescence enlarged, forming a subulate projection to 2 mm long, the apex with a lateral glandular area, the others minute. Inflorescence axillary, subterminal, short-racemose, 10- to 20-flowered, the flowers solitary or paired, the rachis ferruginous-tomentose; floral bud linear-clavate, 2–2.5 cm long, ferruginous-tomentose, the apex with minute free calyx lobes, the pedicel 2–6 mm long; bract and bracteoles lanceolate, ca. 1 mm long. Hypanthium short-tubular, 6–8 mm long; calyx spathaceous at anthesis, soon splitting partly or fully to the hypanthium into 2 to 5 lobes; petals white with pink or roseate base, sometimes lavender-pink or rose, 2–3 cm long, spreading, short-clawed,

glabrous, the blade ovate-elliptic, 6–13(–20) mm wide, the apex rounded, the margin entire, the claw 2–4 mm long; fertile stamens 10, the outer five 2–3 cm long, the inner ones slightly shorter, the filaments free to base or short-connate, short-hirsute or with only a few short trichomes on the lower 1/2, the upper stamen attached near the apex or the middle of the ligulate part of the staminal sheath, short-hirsute (rarely glabrate); gynoecium 2–3 cm long, the gynophore, ovary, and style subequal, the gynophore sparsely tomentose below the ovary on the lower surface or glabrate, the ovary tomentose, the style sparsely tomentellous to glabrate. Fruit linear, 15–25 cm long, ca. 2 cm wide, apiculate with the persistent style, brown, tomentellous to glabrate, the gynophore 1–2 cm long; seeds elliptic-ovate, ca. 15 mm long, ca. 12 mm wide, dark brown, the surface dull, the funicular aril-lobes 6–7 mm long.

Distribution and ecology.—Colombia (Antioquia, Bolívar, Boyaca, Chocó, Cundinamarca, Risaralda, and Santander) and Panama (San Blas). In open to closed forest from near sea level to about 1,500 m.

The species is apparently most closely related to *B. petiolata*, but differs in having bilobed leaves and petals white with a pink or roseate base. The type of *B. ligulata* from Panama is a large tree (40 m) with slightly smaller flowers and the adaxial stamen attached lower on the ligulate portion of the staminate sheath. It agrees in all other respects with the Colombia material. The material from Chocó Province, Colombia differs by its slightly larger leaves (16–21 cm long compared with the usual 4–10 cm long), the glabrate staminal sheath and filament bases (these usally short-hirsute), and the less tomentose ovary.

Bauhinia picta is occasionally cultivated in Colombia for its showy flowers.

Specimens examined. **COLOMBIA. Antioquia:** 14–17 km N of Remedios on the way to Zaragoza, Cerro Cabeza region, along the Río Tucupé (07°20N, 74°30'W), *Callejas et al. 5177* (USF); Vereda Alicante, Finca Penjamo, Quebrada Penjamo, on the San Juan de Bedout–La Cabaña road (06°39'N, 74°31W), *Callejas et al. 9388* (HUA, USF); Vereda La Pava, 14 km by Andes highway toward La Vereda El Líbano, *Fonnegra et al. 2441* (USF); Segovia, *Sandeman 5575* (K). **Antioquia/Bolívar:** near the confluence of the Río Ité and Río Tamar into the Río Cimitarra, ca. 38 km W of Barrancanermeja (06°55'N, 74°15'W), *de Bruijn 1554* (MO, NY, US). **Boyaca:** El Umbo region, *Lawrence 492* (K). **Chocó:** Río Tagachi, ca. 12 km W of Río Atrato (06°15'N, 76°50'W), *Gentry et al. 37068* (MO, USF); Mecana, *Juncosa 1923* (MO, USF). **Cundinamarca:** 16 km NW of Albán along highway to Villeta, *Barclay et al. 3666* (US). **Risaralda:** Hacienda Alejandría, 6 km on La Virginia–Cerritos highway, extreme northern part of Valle del Río Cauca, *Silverstone-Sopkin 5895* (CUVC, USF). **Santander:** Puerto Berrio, between Río Carare and Río Magdalena, *Haught 1772* (P); Bucaramanga and vicinity, *Killip & Smith 14978* (NY). **State unknown**: Río Carare, *Dawe 456* (K); Cordillera Orientale, *Goudot s.n.* (P).

13. Bauhinia seleriana Harms in Loes., Bull. Herb. Boissier 7:549. 1899. TYPE: GUATEMALA. HUEHUETENANGO: near Quen Santo, ca. 1,100 m, *C. Seler & E. Seler 2797* (LECTOTYPE: K, here designated to replace destroyed B holotype; ISOLECTOTYPE: F-fragment, NY, US; photo ex K: F, NY, US; photo ex B: F, G, MO, NY, US;).

Bauhinia paradisi Standley & L.O. Williams, Ceiba 1:80. 1950. TYPE: HONDURAS. EL PARAÍSO: Río Lizapa floresta de Robles area, between Galeras and Lizapa Grande, 1,000 m, 14 May 1948 (fl), *A. Molina 860* (HOLOTYPE: US; photo ex US: NY, US; ISOTYPES: BM, F).

Shrub or small tree to 12 m; branches short-hirsute when young, soon becoming glabrate. Leaves with the blade chartaceous, 9–11-nerved, broadly ovate, bilobate to ca. 1/3 the length, 6–10 cm long, 6–10 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base cordate to rounded, the apex of the lobes obtuse to rounded, the upper surface glabrous, the lower surface short hirsute or tomentellous, the petiole (1–)2–4(–5) cm long, hirsute or tomentellous; stipules triangular-ovate, ca. 4 mm long, caducous; adpetiolar intrastipular excrescence often enlarged and forming a subulate projection to 1.5 mm long, the others minute. Inflorescence terminal or subterminal and axillary, racemose, 5- to 30-flowered, the rachis short-hirsute or tomentellous; floral bud elliptic, 8–15 mm long, short-hirsute or tomentellous, the apex with free lobes to 2 mm long, the pedicel 4–5 mm long; bract and bracteoles lanceolate to linear, 1–4 mm long. Hypanthium cupulate, 1–2 mm long; calyx spathaceous at anthesis; petals white, 11–18 mm long, spreading, subsessile or short-clawed, glabrous except for the blade apex, the blade elliptic, 4–8 mm wide, the apex apiculate, the margin entire, the claw ca. 1 mm long, glabrous; fertile stamens 10, the outer five 11–18 mm long, the inner ones 1/2 the length of the outer, the filaments unequally connate at the base for 1–3 mm, with a laciniate rim extending above the point of adnation, the inner surface tomentose, the anthers linear-oblong, ca. 2 mm long on the longer stamens, ca. 1.5 mm long on the shorter; gynoecium 11–18 mm long, the gynophore, ovary, and style subequal, tomentose. Fruit linear, 8–10 cm long, ca. 1.5 cm wide, apiculate with the persistent style, dark brown, tomentose, the gynophore 0.5–1 cm long; seeds not seen.

Distribution and ecology.—Southern Mexico, Guatemala, and Honduras. Deciduous forest at 700–1,500 m.

The species is closely related to *B. andrieuxii* of western Mexico from which it is distinguished by its larger leaves 6–10 cm long (vs. 2–3 cm in *B. andrieuxii*) and conspicuously hirsute parts. *Bauhinia seleriana* is a forest species while *B. andrieuxii* occurs in open deciduous scrub.

Representative specimens examined: **MEXICO. Chiapas:** along Mexican Highway 190 3 mi S of La Trinitaria, *Breedlove 14485* (NY). **México:** Pungarancho, *Hinton et al. 8570* (K). **Oaxaca:** ca. 3 km to the NE of Laollaga, *Téllez & Magallanes 233* (MEXU, MO). **GUATEMALA. Huehuetenango:** between Nenton and Las Palmas, *Steyermark 51582* (F, US). **Zacapa:** Loma El Picacho, above Santa Rosalia, *Steyermark 42730* (F, NY, US). **HONDURAS. Choluteca:** 6 km SW of Panamerican Highway, *Harmon & Fuentes 5962* (UMO). **El Paraíso:** along Río California, Sierra de la Villa Santa, *Williams & Molina 10479* (F, MO, UC, US, VT). **Francisco Morazán:** along Quebrada Suyapa, near Suyapa, *Molina 553* (F, MO, US).

14. Bauhinia seminarioi Harms ex Eggers, Bot. Centralbl. 73:69. 1898. TYPE: ECUADOR. MANABÍ: near Hacienda El Recreo, 16 Aug 1893 (fl, fr), *H.F.A. von Eggers 14925* (LECTOTYPE: F-fragment, here designated to replace destroyed B holotype; photo ex B: ISOLECTOTYPES: F, MO, US).

Shrub or small tree 2–3(–5) m; branches sparsely tomentellous when young,

soon becoming glabrate. Leaves with the blade submembranaceous to chartaceous, (5–)7–9-nerved, suborbicular, bilobed to ca. 1/2 the length, 5–13 cm long, 6–12 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base cordate, the apex of the lobes obtuse to rounded, the upper surface glabrous, the lower surface minutely strigulose, short-pilose along the veins, especially near the base, the petiole 2–4.5 cm long, tomentellous, soon becoming glabrate; stipules triangular-lanceolate, ca. 1 mm long, caducous; adpetiolar intrastipular excrescence occasionally enlarged and forming a subulate projection to 2 mm long, the others minute. Inflorescence terminal or subterminal and axillary, racemose, 8- to 18-flowered, the flowers usually paired, the rachis tomentellous to glabrate; floral bud linear-clavate, 4–6 cm long, tomentellous to glabrate, the apex rounded, the pedicel 0.5–1.8 cm long; bract and bracteoles triangular-lanceolate, 0.5 mm long. Hypanthium short-tubular, 1.5–2 cm long; calyx spathaceous at anthesis; petals white, ca. 5 cm long, slightly spreading, short-clawed, glabrous, the blade linear-oblanceolate, 5–6 mm wide, the apex acute to obtuse, the margin slightly crisped, the claw ca. 0.5 cm long; fertile stamens 10, the outer five ca. 4 cm long, the inner ones slightly shorter, the filaments short-connate at the base to ca. 6 mm, the staminal sheath pilose on the inner surface near the apex and slightly above on the filaments, the anthers elliptic-oblong, ca. 5 mm long, glabrous; gynoecium 5.5–6.5 cm long, the gynophore, ovary, and style subequal, glabrous. Fruit linear, 15–25 cm long, 2–2.3 cm wide, apiculate with the persistent style, dehiscent, brown, glabrous, the gynophore 2–3 cm long; seeds not seen.

Distribution and ecology.—Ecuador (Guayas and Manabí). Tropical moist forest on inner coastal hills at 100–150 m.

The type collection (*von Eggers 14925*) is apparently a mixture of this species and *Bauhinia aculeata* subsp. *grandiflora* (Jussieu ex Poiret) Wunderlin of subg. *Bauhinia* section *Bauhinia*. Specimens of *B. aculeata* subsp. *grandiflora* with various collection dates were distributed as the type of *B. seminarioi* by C to K, F, and undoubtedly elsewhere. The description, except for the statement that the species is aculeatous, clearly fits what is known to be *B. seminarioi* as represented by the photograph of the holotype (now destroyed) and not *B. aculeata* subsp. *grandiflora*. The adpetiolar intrastipular excrescences in *B. seminarioi* sometimes enlarge to 2 mm, especially in the inflorescence, but the older branches can not be described as aculeatous. Since the holotype is of young floriferous material with evident enlarged excrescences, Harms apparently incorrectly interpreted the materia. The *Iltis & Iltis E-221* specimen bears only small blunt excrescences.

Specimens examined. **ECUADOR. Guayas:** Bosque Protector Cerro Blanco, road to Salinas, 15 km (02°10'S, 79°58'W), *Rubio 2020* (MO, USF). **Manabi:** Hacienda El Recreo, *von Eggers 14886* (F, K, P, US); 4 km E of Hacienda El Recreo (2 km S along coast from Canoa, 18 km due N of Bahía de Caraquez; 00°27'S, 80°26'W) and the Pacific Ocean, *Iltis & Iltis E-221* (USF, WIS).

15. Bauhinia weberbaueri Harms, Bot. Jahrb. Syst. 42:91. 1908. TYPE: PERU. CAJAMARCA: near Rambrán, 2,000–2,100 m, Jan 1905 (fl), *A. Weberbauer 4802* (LECTOTYPE: G, here designated to replace destroyed B holotype; ISOLECTOTYPE: F-fragment; photo ex B: F, MO).

Bauhinia ruiziana Harms, Repert. Spec. Nov. Regni Veg. 18:234. 1922. TYPE: PERU. HUANUCO: Ambo, 1778–1788 (fl), *H. Ruiz López 1795* [*H. Ruiz López & J.A. Pavón 1300*] (LECTOTYPE: K, here designated to replace destroyed B holotype; ISOLECTOTYPES: F, MA, not seen, P; photo ex K, F, US; photo ex MA, F; photo ex B, F, G, MO, US).

Shrub to 1.5 m; branches strigulose when young, soon becoming glabrous. Leaves with the blade chartaceous, 7-nerved, suborbicular, bilobed to ca. 3/4 the length, 1.5–4 cm long, 1.5–4 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base cordate, the apex of the lobes obtuse to rounded, the upper surface glabrous, the lower surface strigulose, the petiole 0.5–1 cm long, minutely strigulose or glabrous; stipules triangular-lanceolate, 1–1.5 mm long, caducous; adpetiolar intrastipular excrescence occasionally enlarged and forming a subulate projection to 2 mm long, the others minute. Inflorescence terminal or subterminal, the flowers solitary, the rachis strigulose; floral bud elliptic-lanceolate, ca. 2 cm long, red, strigulose, the pedicel ca. 1 cm long; bracts and bracteoles triangular, ca. 1 mm long. Hypanthium short-tubular, 4–6 mm long; calyx spathaceous at anthesis; petals bright pink or rose-red, 3–4 cm long, spreading, short-clawed, glabrous, the blade oblanceolate, 1–1.8 cm wide, the apex rounded, the margin entire, the claw 3–5 mm long; fertile stamens 10, red, the outer five 2.5–3 cm long, the inner ones slightly shorter, the filaments very short-connate, sparsely pilose toward the base, the anthers elliptic-oblong, 3–4 mm long, glabrous; gynoecium 3–4 cm long, the gynophore, ovary, and style subequal, glabrous. Fruit narrowly elliptic, 4.5–5 cm long, ca. 1.5 cm wide, apiculate with the persistent syle, dehiscent, light brown, glabrous, the gynophore 4.5–5 cm long; seeds irregularly elliptic-ovate, dark brown, the surface dull, the funicular aril-lobe scars subequal, 2–3 mm long.

Distribution and ecology.—Peru (Cajamarca, La Libertad, and Huánuco). On steep rocky slopes above rivers at 2,100–2,400 m.

Bauhinia weberbaueri is related to *B. ayabacensis* and *B. augusti*, but is easily distinguished from both by its glabrous ovary (vs. tomentose in *B. augusti* and *B. ayabacensis*) and from *B. augusti* by its pink to rose petals (vs. white in *B. augusti*).

Specimens examined. **PERU. La Libertad:** between Los Alisos and Pataz, *Alayo 18* (USF). **Huánuco:** above Hacienda Quicacan, between Ambo and Huánuco, *Ferreyra 6553* (F); Ambo, *Macbride & Featherstone 2411* (F), *Macbride 3164* (F, G), *Pavon s.n.* (BM), *Sawada P-103* (F); Huánuco, *Macbride 3503* (F, G), *Matthews 927* (K), without precise locality, Vita, *McLean s.n.* (K).

II. Series **Stenanthae** Wunderlin, K.Larsen & S.S.Larsen, Biol. Skr. 28: 14. 1987.
TYPE: *Bauhinia stenantha* Diels.

Petals strongly imbricate, the corolla forming a pseudotube; fertile stamens 5.

1. Bauhinia stenantha Diels, Biblioth. Bot. 29(116):93. 1937. TYPE: ECUADOR. CHIMBORAZO: canyon of the Río Chanchan near Huigra, 1,220–1,370 m, 7–14 May 1945 (fl, fr), *W.H. Camp E-3041* (NEOTYPE: F, here designated to replace destroyed B holotype; ISONEOTYPE: K, P). [ECUADOR. CHIMBORAZO: canyon of the Río Chanchan near Huigra, 1,260 m, 21 Sep 1933 (fl, fr), *F.L.E. Diels 1130* (HOLOTYPE: B, destroyed)].

Shrub or small tree to 3 m; branches puberulent when young, soon becoming glabrate. Leaves with the blade submembranaceous or chartaceous, 7–9-nerved, suborbicular, bilobed to ca. 3/4 the length, 2.5–5.5 cm long, 3–5.5 cm wide, the innermost pair of lateral nerves equidistant or closer to the adjacent lateral nerves than to the mid-nerve, the base cordate, the apex of the lobes obtuse to rounded, the upper surface glabrous, subglaucous, the lower surface sparsely to moderately tomentose, the petiole 1–3 cm long, tomentellous to glabrate; stipules triangular-ovate, ca. 1 mm long, caducous; adpetiolar intrastipular excrescence occasionally enlarged and forming a subulate projection to 2 mm long, the others minute. Inflorescence terminal or subterminal, short-racemose, 2- to 10-flowered, the rachis tomentellous or strigulose; floral bud elliptic-oblanceolate, ca. 2.5 cm long, rose-red, tomentellous or strigulose, the apex apiculate, the pedicel 1–1.5 cm long; bract and bracteoles triangular-lanceolate, ca. 1 mm long. Hypanthium short-tubular, subgibbous at the base, 6–8 mm long; calyx spathaceous at anthesis, soon splitting to the hypanthium into 2 to 5 lobes; petals rose-red, 2.5–3 cm long, erect and pseudotubular, short-clawed, glabrous, the blade oblanceolate, 7–8 mm wide, the apex rounded, the margin slightly crisped, the claw 8–9 mm long; fertile stamens 5, red, 2.5–3 mm long, the filaments very short-connate, the staminal sheath with a small laciniate rim, glabrous, the anthers oblong, ca. 5 mm long, glabrous, the staminodes 5, rudimentary or to 1/2 the length of the fertile stamens, the aborted anthers globose; gynoecium 3.5–4.5 cm long, the gynophore, ovary, the style subequal, glabrous. Fruit linear, 6–10 cm long, ca. 1.5 cm wide, apiculate with the persistent style base, dehiscent, light brown, glabrous, the gynophore ca. 1.5 cm long; mature seeds not seen.

Distribution and ecology.—Ecuador (Azuay and Chimborazo). Dry scrub hillsides at (600–)1,200–1,800 m.

Specimens examined. **ECUADOR. Azuay:** along Pasaje–Santa Isabel–Girón highway, valley of the Río Jubones, *Harling & Andersson 14404* (GB, USF); Cuenca–Machala road, between Girón and Santa Isabel, 17 km from Girón (03°14'S, 79°13'W), *Løjtnant & Molau 14176* (AAU); 17 km SW of Girón, *MacBryde 451* (MO). **Chimborazo:** Huigra, *Asplund 7736* (S), *Asplund 15507* (K, S); vicinity of Huigra, *Rose & Rose 22119* (photo ex NY: US); Huigra, *White s.n.* (BM). **State unknown:** without definite locality, *Acosta-Solís 11675* (F).

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DENDROPHORBIUM RESTINGAE (ASTERACEAE: SENECIONEAE), A NEW SPECIES FROM SÃO PAULO, BRAZIL

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ABSTRACT

Dendrophorbium restingae (Asteraceae: Senecioneae), a new species from São Paulo state, Brazil, is described, illustrated, and compared with the related species *D. paranense* (Malme) Matzenb. & Baptista.

RESUMEN

Dendrophorbium restingae (Asteraceae: Senecioneae), una nueva especie de São Paulo, Brasil, es descrita, ilustrada y comparada con la especie relacionada *D. paranense* (Malme) Matzenb. & Baptista.

Dendrophorbium (Cuatrec.) C. Jeffrey is a predominantly Andean genus with about 50 species ranging from the Antilles to southern Brazil (Jeffrey 1992). Hind (1993) recorded nine species for Brazil; some years later Matzenbacher and Baptista (1997) proposed one more new combination in the genus, for a total of ten Brazilian species.

Dendrophorbium was segregated from the large genus *Senecio* (Nordenstam 1996), and is recognized by its large and generally dentate leaves, corymbiform to paniculiform capitulescences, radiate heads with 8–13 glabrous phyllaries, style branches with a truncate, obtuse, or conical apex bearing a tuft of trichomes, and 5–8-ribbed cypselae with an annuliform carpopodium (Nordenstam 1996).

Dendrophorbium restingae A.Teles, J.N.Nakaj. & Stehmann, sp. nov. (**Figs. 1a, b, 2**). TYPE: BRAZIL. SÃO PAULO: Município de Peruíbe, Estação Ecológica Juréia-Itatins, restinga da praia do Arpoador, 22 Jun 1994, *I. Cordeiro, M.M.R. Fiúza de Melo, R.J. Oliveira & M. Barros 1531* (HOLOTYPE: SP; ISOTYPE: K).



FIG. 1a. Habit of *Dendrophorbium restingae*, details of heads in upper corner right (holotype, SP).



FIG. 1b. Basal leaves (holotype, SP).

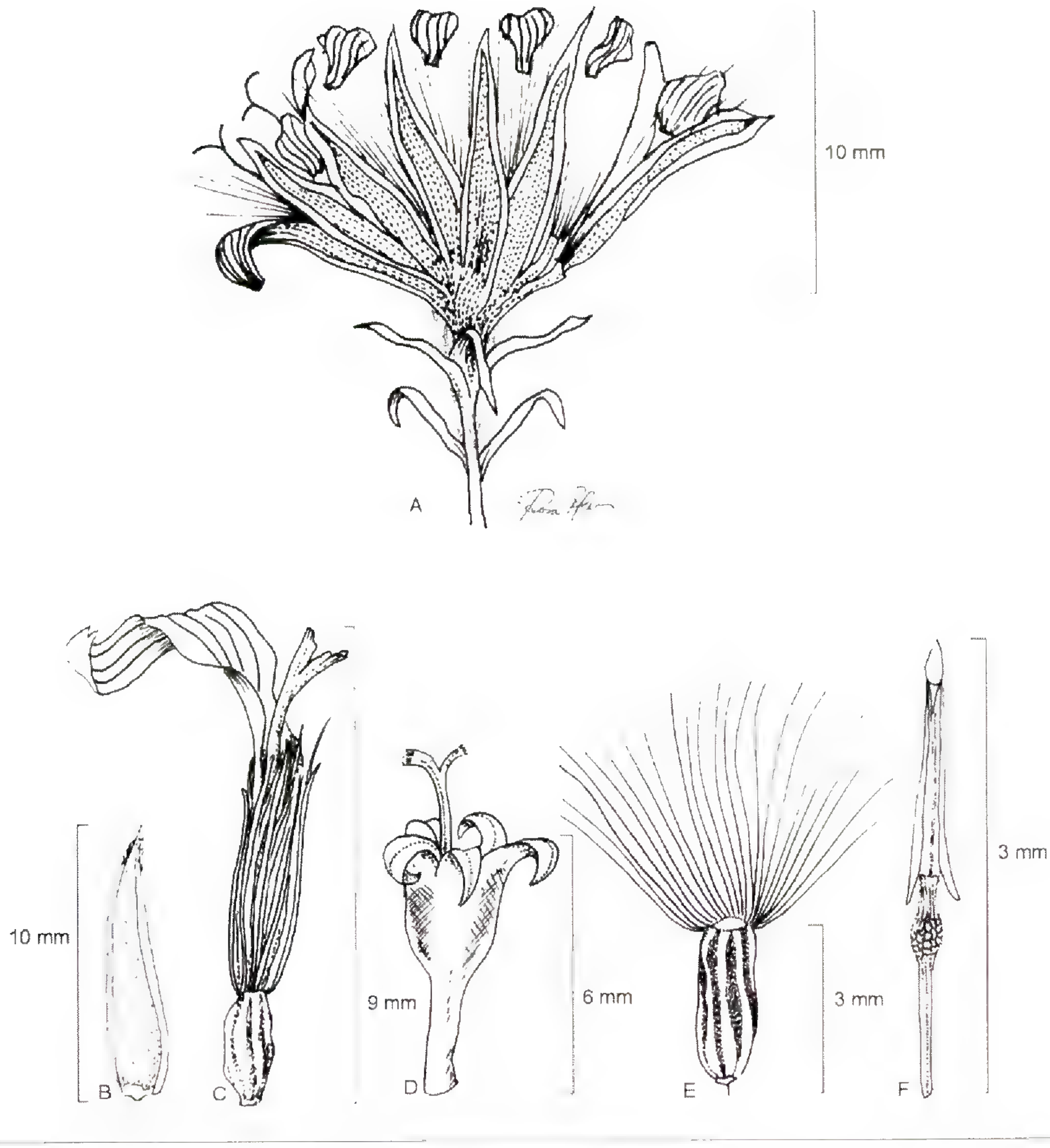


Fig. 2. *Dendrophorbium restingae*. A. Head. **B.** Phyllaries. **C.** Ray floret. **D.** Disk floret. **E.** Cypselae of disk floret. **F.** Stamen. **All from the holotype (SP).**

A *Dendrophorbium paranense* affinis, sed foliis majoribus valde cordatis (vs. sagittatis) marginibus crenulatisque (vs. regulariter dentata), petiolis non auriculatis, floribus disci 30–35 (vs. usque 25) et cypselis 5–8-costatis (vs. 10-costatis) differt.

Robust herbs 1–1.5 m high. Stems fistulose, multisulcate and lanate. **Leaves** alternate, coriaceous, discolorous, glabrous and brownish adaxially and greyish-tomentose abaxially when dry, penninervate with 9–16 secondary veins prominent abaxially, margins crenulate; basal leaves non-auriculate, petiolate, the petioles 5.5–12 cm long, winged, clasping the stem, lanate, the blades ovate-cordate, 7–35 cm long, 6.5–26 cm wide, with apex acute, base cordate; distal leaves sessile and invaginating, the blades oblong, 2–14 cm long, 0.7–3.5 cm wide, with acute apex and obtuse base. **Capitulescences** corymbiform. **Heads** heterogamous,

radiate, peduncle 1–4 cm long, lanate, bracteole lanceolate. **Involucres** 1–1.3 cm long, 1–1.2 cm wide, campanulate, calyculate, calyculus 5-bracteolate, bracteole 5–6 mm long, linear, glabrous; phyllaries ca. 13, uniseriate, lanceolate, 10–11 mm long, 1.5–2 mm wide, the apex acute and ciliate, the margins glabrous and scarious. **Receptacles** plane, alveolate, epaleaceous. **Ray florets** 4–8, pistillate; corolla liguliform to 13 mm long, bidentate to tridentate apically; style to 10 mm long, branches straight, ca. 1 mm long, the apex with a tuft of pennicilate trichomes. **Cypselae** 3–4 mm long, cylindrical, 5-ribbed, glabrate, with inconspicuous carpopodium; pappus ca. 7 mm long, deciduous. **Disk florets** perfect, 30–35; corolla tubulose, 7–9 mm long, 5-lobate, the lobes 2.5–3 mm long, the midvein visible along the distal half of the tube; stamens with anthers to 3 mm long, exserted, caudate at base to 0.2 mm long, the filaments with anther collar dilated, the connective with an oblong conspicuous appendage to 1 mm long; style 7–12 mm long, branches 1–2.5 mm long, divergent, apex truncate crowned by simple trichomes. **Cypselae** 3–5 mm long, cylindrical, 5–8ribbed, glabrate, carpopodium annuliform; pappus 6–7 mm long, deciduous.

Dendrophorbium restingae morphologically resembles *Dendrophorbium paranense* (Malme) Matzenb. & Baptista, but is distinguishable by its crenulate and larger leaves and more ray florets, as well as its distinct geographical range and habitat. The new species so far has been collected only in coastal forests on sandy soils of the state of São Paulo. This area belongs to the edaphic vegetational complex called Restinga that occupies a narrow belt along the Brazilian coast (Veloso et al. 1991; Rizzini 1997). Other endemic species of Asteraceae growing in this environment, such as species of *Noticastrum* from Santa Catarina and Rio Grande do Sul (Zardini 1985) and *Litothamnus* from Bahia (Holmes 1996). Additionally, *D. paranense* occurs in humid soils of riverine habitats in the cloud forests of Paraná, Santa Catarina, and Rio Grande do Sul. Both species can be distinguished by the characters set in the following key:

Leaves coriaceous with crenulate margins; petioles not auriculate; phyllaries apically ciliate; disk florets 30–35, corollas 7–9 mm long; cypselae of disk florets 5–8-ribbed
_____ **D. restingae**

Leaves papyraceous with dentate margins; petioles auriculate; phyllaries apically penicillate; disk florets 22–25, corollas 3.5–5 mm long; cypselae of disk florets 10-ribbed
_____ **D. paranense**

Etymology.—The epithet alludes to the habitat of the species, the Brazilian coastal vegetation on sandy soils named restinga. Until the present, no species of this genus had been collected in this vegetation.

Geographical distribution and habitat.—This species so far has been collected only in restinga vegetation at the Juréia-Itatins Ecological Station, in the municipality of Peruíbe in the state of São Paulo, where it grows in rocky places along the shore line.

Phenology.—Flowers and fruits were collected from June to October.

PARATYPE: **BRAZIL. São Paulo:** Estação Ecológica de Juréia-Itatins, Município de Peruíbe, núcleo, praia do Arpoador, vegetação de restinga arbustiva, 18 Oct 2004, *Moreno et al. 100* (SP).

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NOVEDADES EN GENTIANACEAE PARA AMÉRICA DEL SUR

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ABSTRACT

Gentianella fabrisii (Gentianaceae) is proposed as a new species. It is known only from the type collection from the northwestern of Argentina (Prov. Tucumán); a key to distinguish this species from its closer relatives is provided. New synonyms for *Cicendia quadrangularis*, *Curtia tenuifolia*, *Gentiana prostrata*, *Zygostigma australe* and for 4 species of *Gentianella* are proposed. The ocurrence of *Chelonanthus viridiflorus* and *Schultesia guianensis* in Argentina and Paraguay is confirmed. These two last species are described and illustrated in detail.

RESUMEN

Se describe e ilustra una nueva especie de *Gentianella* (*G. fabrisii*), que habita en el noroeste de la Argentina (Prov. Tucumán), y se provee una clave para diferenciarla de sus congéneres más próximos. Se dan a conocer nuevos sinónimos para *Cicendia quadrangularis*, *Curtia tenuifolia*, *Gentiana prostrata*, *Zygostigma australe* y para 4 especies de *Gentianella*. Se confirma la presencia de *Chelonanthus viridiflorus* y *Schultesia guianensis* para la Argentina y Paraguay, las que se describen e ilustran detalladamente.

INTRODUCCIÓN

Gentianaceae es una familia cosmopolita, ausente sólo en el continente antártico, con ca. 1690 especies que habitan, por lo común, en regiones templadas, subtropicales y tropicales (Struwe et al. 2002). Una moderna clasificación en tribus y subtribus basada, en gran parte, en estudios filogenéticos derivados de datos moleculares (*trn*L, *mat*K e ITS), acepta 6 tribus y 87 géneros (Struwe et al. 2002). Esta familia se caracteriza por presentar algunas entidades bien conocidas por sus principios amarogénicos y colorantes, de uso tanto en la industria alimenticia como en la farmacéutica (Jensen & Schripsema 2002).

En el Nuevo Mundo, la mayor diversidad de géneros (de 47 nativos, 36 son endémicos) se encuentra en la región tropical de América Central y América del Sur (Struwe et al. 2002). Con motivo de estar realizando la revisión de Gentianaceae para el Catálogo del Cono Sur y para la Flora Fanerogámica de Argentina, surgieron algunas novedades, que ya se dieron a conocer en parte (Filippa & Barboza 2001; 2003), a las que se suman ahora las de la presente contribución.

UNA NUEVA ESPECIE DE *GENTIANELLA*

Gentianella fabrisii Filippa et Barboza, sp. nov. (**Fig. 1**). TIPO: ARGENTINA. TUCUMAN. Dpto. Tafí: Quebrada del Barón, Los Planchones, 3300 m, 7 Feb 1958, *H.A. Fabris 1417 a* (HOLOTIPO: BM; ISOTIPO: *H.A. Fabris 1417 a pp.*, LP).

A *Gentianella bromifolia* foliis ovatis vel late ovatis, floribus hermaphroditus et femineis, calycis lobis anguste ovatis, corollae lobis tubo 3–5 plo longioribus, gynoecio sessili differt.

Hierba anual, ginomonoica, erecta, hasta ca. 40 cm alt, glabrescente. **Tallo** solitario, laxamente ramificado desde la base o más arriba, poco hojoso. **Hojas** sésiles, las basales escasas, con lámina espatulada, base atenuada en pseudopecíolo y ápice agudo, hojas caulinares sésiles, ovadas a anchamente ovadas, agudas, con 3–5-nervios sobresalientes en el hipofilo, de 10–44 mm long. × 5–15 mm lat., con tricomas glandulares no capitados en la base foliar adaxial. **Flores** terminales solitarias o en cimas 3–5-floras, raro 8-floras y flores axilares solitarias o geminadas; pedicelos de 20–60 mm long.; cáliz acrescente y persistente, de 10–16 mm long., lóbulos angosto-ovados, agudos, desiguales, hasta 3 veces más largos que el tubo, tubo con anillo de tricomas glandulares pluricelulares en su borde inferior interno, de 3–5 mm long.; corola lila, violácea oscura en la base de cada lóbulo, de 17–26 mm long., tubo breve (5–7 mm long.), glabrescente, con tricomas glandulares pluricelulares por encima de la unión de los estambres, lóbulos elípticos a espatulados, agudos, de 10–19 mm long., 3–5 veces más largos que el tubo, nectarios epipétalos en U; filamentos estaminales planos, más largos que la altura media de la corola e insertos cerca de la mitad inferior del tubo en las flores perfectas, anteras versátiles (primero introrsas, y extrorsas en la dehiscencia), elipsoides, inclusas, de ± 3 mm long, tecas libres en su tercio inferior; en las flores pistiladas, estambres reducidos a estaminodios (filamentos breves con anteras atrofiadas, vacías); gineceo angosto-elipsoide, sésil, lóbulos estigmáticos ovados. **Cápsula** de color marrón claro, cuando madura excede la corola persistente. **Semillas** numerosas, castaño oscuras, subesféricas, menores de 1 mm de diám., con tegumento levemente reticulado.

Etimología.—El epíteto se debe a Humberto A. Fabris (1924–1976), destacado docente e investigador botánico argentino, quien coleccionó el material tipo y dedicó una buena parte de su vida al estudio de las Gentianaceae, en especial *Gentianella*, de América del Sur.

Observación.—En la colección tipo de *G. fabrisii* se encontraron semillas maduras provenientes de frutos derivados tanto de las flores pistiladas como de las perfectas (Fig. 1 F–H).

Hábitat y distribución geográfica.—Hasta el momento, sólo se conoce esta especie por el material tipo, proveniente de las montañas del oeste de la Prov. de Tucumán, por arriba de los 3000 m. Al igual que sus congéneres, habita en praderas húmedas de altura donde convive con *Gentianella bromifolia* (Griseb.) T.N. Ho et S.W. Liu.

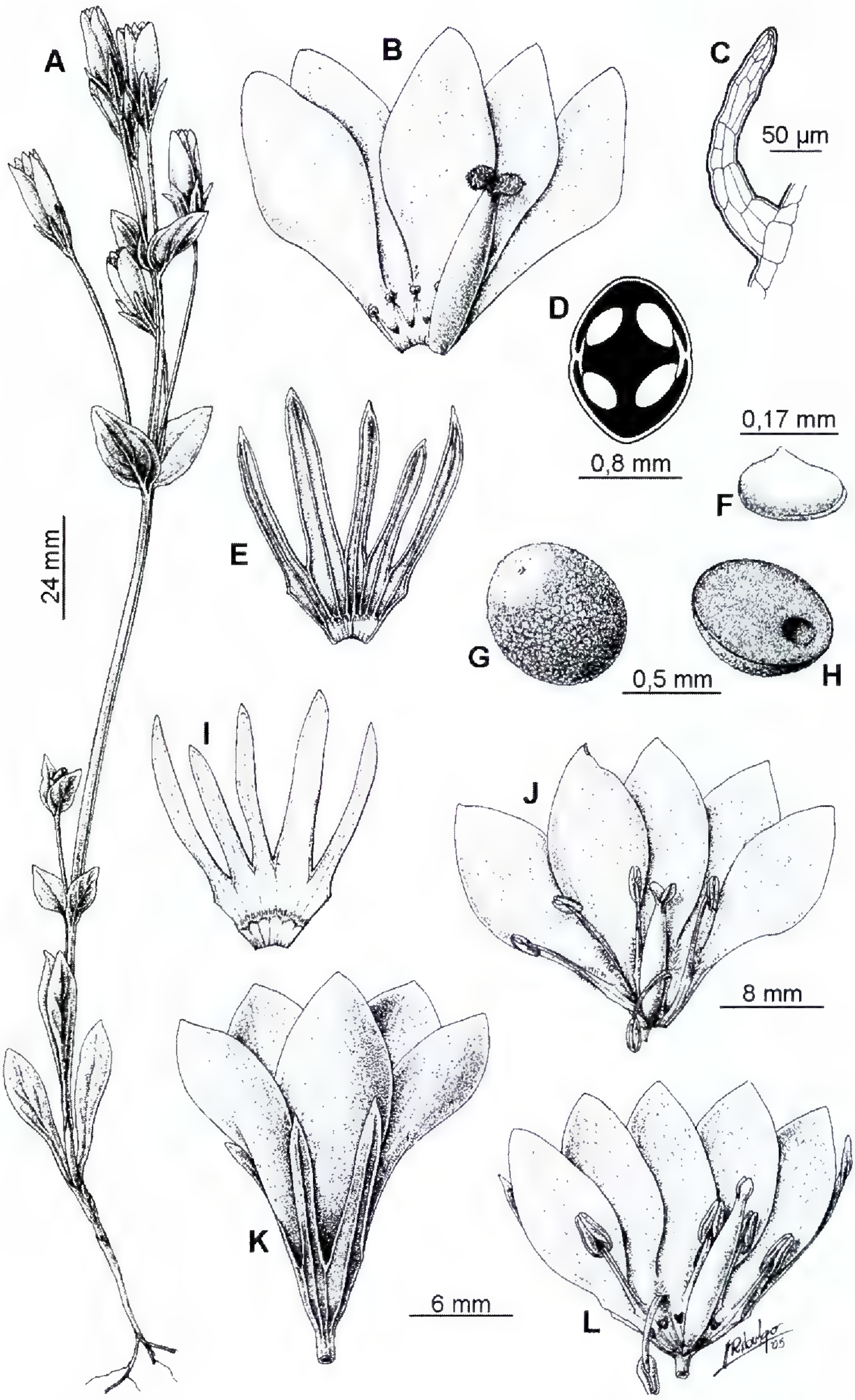


FIG. 1. *Gentianella fabrisii*. **A.** Hábito. **B.** Corola desplegada de flor pistilada. **C.** Tricoma de la corola. **D.** Transcorte de ovario. **E.** Cáliz, vista externa. **F.** Embrión. **G.** Semilla, vista lateral. **H.** Transcorte por semilla (se ha eliminado el embrión). **I.** Cáliz, vista interna con anillo basal de tricomas. **J.** Corola desplegada de flor perfecta, obsérvense las anteras maduras extrorsas. **K.** Flor, vista lateral. **L.** Botón floral desplegado, obsérvense las anteras jóvenes introrsas. La escala de 6 mm vale para B, E, I, K, L. De *Fabris 1417a*.

Gentianella fabrisii es afín a *Gentianella bromifolia* por compartir la ramificación de los tallos, la longitud de los pecíolos, la disposición de las flores, y la forma y el color de los lóbulos corolinos; se diferencian por su sexualidad (planta ginomonoica vs. planta monoico-monoclina), la forma de las hojas caulinares (ovadas a anchamente ovadas vs. linear-elípticas), la forma de los lóbulos calicinos (angosto-ovados, agudos vs. linear-triangulares, aleznados), la relación longitud tubo/lóbulos de la corola (1/3–1/5 vs. 1/2–1/3) y por el gineceo (sésil vs. estipitado).

En los tratamientos de Gilg (1906, 1916), ya se hace mención de la presencia de poligamia entre las especies de *Gentianella* (sub nom. *Gentiana*). Si bien la mayoría de las especies poseen flores monoclinas, se pudo comprobar que de las 29 especies que crecen en la Argentina, en 5 de ellas ocurre ginomonoecia, entre las que se encuentra *G. fabrisii*, en tanto que solamente *G. florida* presenta ginodioecia (Juárez de Varela 1997; Filippa & Barboza, inédito). Un caso muy particular es el de *G. thiosphaera* debido a la ocurrencia de trimonoecia (según Font Quer 1979), es decir flores perfectas en su mayoría, y pocas estaminadas y pistiladas en un mismo individuo (Filippa & Barboza 2001).

LAS 7 ESPECIES POLÍGAMAS DE LA ARGENTINA
SE DIFERENCIAN EN LA SIGUIENTE CLAVE

1. Inflorescencias terminales densas. Anteras hasta de 2 mm long. Pedicelos cortos, de 2–23 mm.
   2. Corola blanca o blanco-amarillenta, con tubo notablemente más corto que los lóbulos. Anteras completamente exertas. Plantas ginodioicas _____ **G. florida**
   2. Corola amarilla o lilacina, con tubo más largo que los lóbulos o de igual longitud. Anteras inclusas o apenas exertas. Plantas no ginodioicas.
      3. Tubo corolino dos a tres veces más largo que los lóbulos. Gineceo con ginóforo de 2–6 mm. Plantas trimonoicas _____ **G. thiosphaera**
      3. Tubo corolino igual o apenas más largo que los lóbulos. Gineceo sésil. Plantas ginomonoicas.
         4. Corola amarilla. Flores axilares en verticilos. Hojas opuestas o en verticilos trímeros _____ **G. multiflora**
         4. Corola lilacina. Flores axilares no verticiladas. Hojas siempre opuestas _____ **G. imberbis**
1. Inflorescencias terminales laxas o bien flores solitarias. Anteras de 2–4 mm. Pedicelos comparativamente largos, de 15–90 mm.
   5. Tallo solitario. Hojas ovadas a anchamente ovadas. Lóbulos calicinos angosto-ovados _____ **G. fabrisii**
   5. Tallos numerosos. Hojas elípticas o angosto- a linear-elípticas. Lóbulos calicinos triangulares a linear-triangulares.
      6. Hojas caulinares elípticas, siempre opuestas. Nectarios en V. Semillas de 1–1,1 mm × 0,7–0,9 mm _____ **G. kurtzii**
      6. Hojas caulinares angosto- a linear-elípticas, opuestas o en verticilos trímeros. Nectarios en U. Semillas de 0,5–0,9 mm × 0,3–0,4 mm _____ **G. myriantha**

NUEVOS SINÓNIMOS PARA ESPECIES DE GENTIANACEAE

CICENDIA

Cicendia quadrangularis (Lam.) Griseb., Gen. sp. Gent. 157. 1839. BASÓNIMO: *Gentiana quadrangularis* Lam., Encycl. 2:645. 1788. TIPO: PERU: "Environs of Lima," *Dombey s.n.* (HOLOTIPO: P!)

Gentiana flava Larrañaga, Escritos de Don D.A. Larrañaga 2:100. 1923. TIPO: No citado. **Syn. nov.**

Si bien el herbario de Larrañaga fue destruido por acción de los insectos (Alonso Paz, com. pers.), gran parte de su obra escrita pudo rescatarse y fue publicada en varias etapas; en 1923, se dieron a conocer las descripciones de las especies y cuatro años más tarde (1927) - en el Atlas (Parte I. Botánica)-, las magníficas ilustraciones de referencia.

Cuando Larrañaga describe *Gentiana flava* no precisa ningún material tipo, sólo señala que se encuentra "...en todos los prados; pero es tan pequeña que se confunde muy fácilmente con el pasto tierno entre que se oculta." La diagnosis es breve (planta muy pequeña, tallo poco ramificado y unifloro, hojas lineares, corola tetrámera, glabra, amarilla, hipocrateriforme); sin embargo, los caracteres que utiliza, refrendados por la ilustración (Lám. LXXVI), son lo suficientemente precisos para decidir su sinonimia con *Cicendia quadrangularis*.

CURTIA

Curtia tenuifolia (Aubl.) Knobl., Bot. Zentralbl. 60:357. 1894. (**Fig. 2**). BASÓNIMO: Exacum tenuifolium Aubl., Hist. pl. Guiane 1:70, t.26, f.2. 1775. TIPO: "Habitant in pratis humidis Caïennæ & Guianæ" (P!).

Curtia montevidensis Arechav., Anales Mus. Nac. Montevideo ser. 2, 1:65, f.3. 1911. TIPO: [URUGUAY]. "Montevideo, arenales húmedos de Carrasco," Abr 1874, *J. Arechavaleta 163* (HOLOTIPO: MVM!). **Syn. nov.**

Arechavaleta (1911) describe *C. montevidensis* sin mencionar los caracteres que la diferencian de sus congéneres. El hábito y la disposición, forma y longitud de las hojas (opuesta, linear-subulada y ca. 4 mm long.) y la longitud del cáliz y corola (ca. 4 mm y 5 mm long. respectivamente) observados en el material tipo, son coincidentes con los de *C. tenuifolia*.

Por otro parte, cuando Fabris (1973) cita por primera vez la existencia de *Curtia malmeana* en la Argentina, destaca su afinidad y posible sinonimia con *C. tenuifolia* (esta situación está propuesta en una preliminar Checklist de Bolivia virtual: www.efloras.org). Mediante el análisis del material tipo de *C. malmeana* (Brasil: *Malme 424b*, S!), corroboramos esta sinonimia. De esta manera, *Curtia tenuifolia* (Fig. 2), es la única especie que crece en la Argentina (Prov. Corrientes) y sur de Uruguay (Dpto. Montevideo y Canelones).

GENTIANA

Gentiana prostrata Haenke, Collectanea 2:66, pl.17, f.2. 1789. TIPO: "Rara habitat in jugis nivosis alpium Kartal et Frosnitz, principatus Salisburgensis ...". (n.v.).

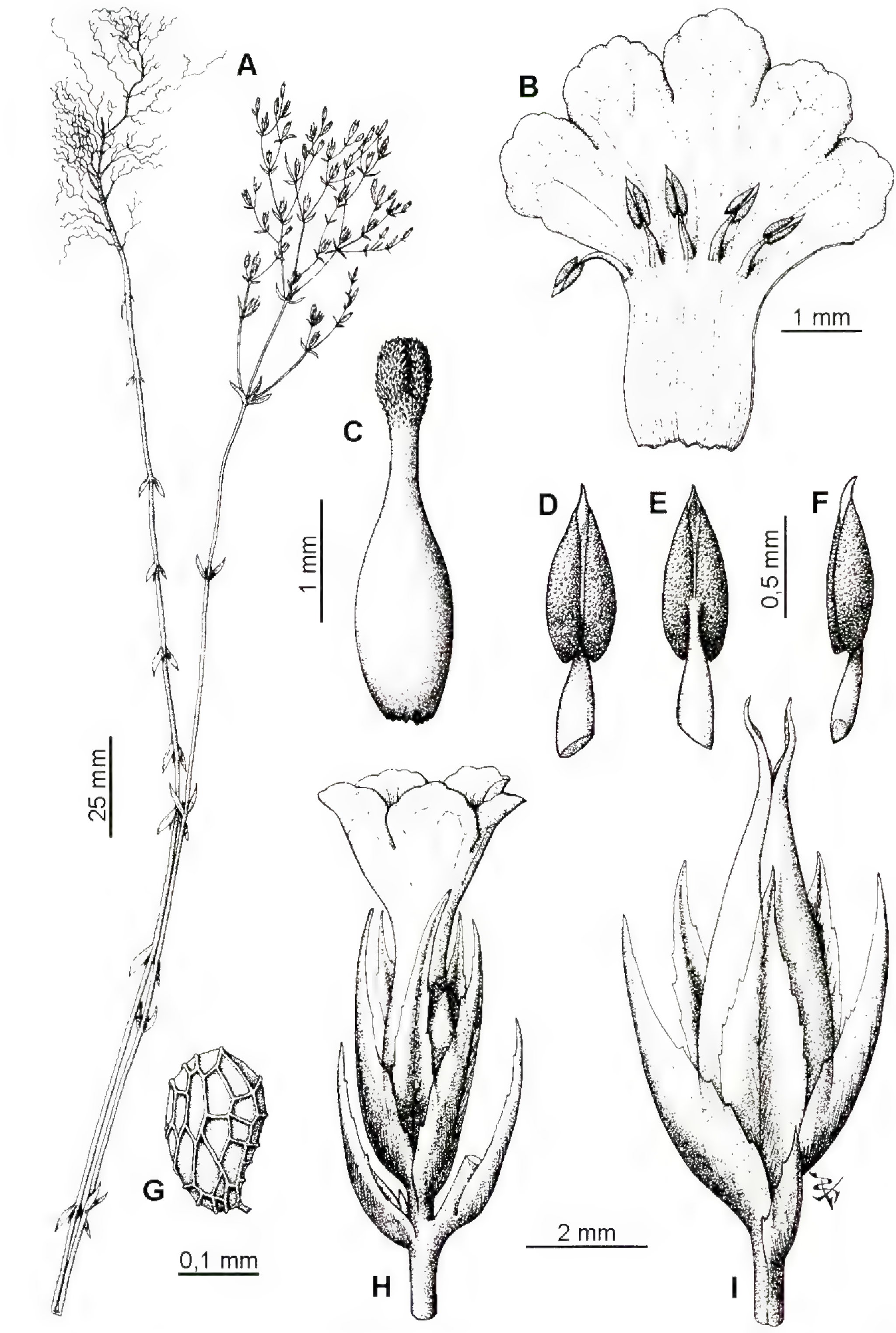


FIG. 2. *Curtia tenuifolia*. **A.** Hábito. **B.** Corola despelgada. **C.** Gineceo. **D–F.** Anteras en vista ventral, dorsal y lateral respectivamente. **G.** Semilla con episperma reticulado. **H.** Flor. **I.** Fruto con cáliz persistente. De *Pedersen 8740*.

Gentiana minima Phil., Linnaea 29:13. 1858. TIPO: CHILE: "In Andibus interioribus prov. Santiago," *Philippi s.n.* (HOLOTIPO: SGO 053950!). **Syn. nov.**

Fabris (1953) hace referencia al gran polimorfismo que presenta *G. prostrata*, lo que ha motivado una profusa sinonimia para esta especie (Fabris 1983). *Gentiana minima*, descripta para Chile, ha pasado inadvertida en la literatura de los últimos años. El análisis del holotipo depositado en SGO, puso en evidencia que se trata de un sinónimo más de *G. prostrata*.

GENTIANELLA

Gentianella cosmantha (Griseb.) J.S. Pringle, Phytologia 48:281. 1981. BASÓNIMO: *Gentiana cosmantha* Griseb., Pl. lorentz.: 161. 1874. TIPO: ARGENTINA. TUCUMÁN: Cuesta de la Casilla, Apr 1872, *Lorentz 774* (HOLOTIPO: B!; ISOTIPO: CORD!).

Gentianella cosmantha f. *violacea* Fabris, en A.L. Cabrera (dir.), Flora prov. Jujuy 8:66. 1983. TIPO: ARGENTINA. JUJUY: Dpto. Capital, Laguna de Yala, 26 Mar 1979, *A.L. Cabrera et al. 30678* (HOLOTIPO: SI!). **Syn. nov.**

Fabris (1983) diferencia la f. *violacea* de la f. *cosmantha* por el tamaño y color de la corola (más pequeña y de color violáceo en vez de rojo o rojo-anaranajado). Las observaciones realizadas a campo y de ejemplares de herbarios provenientes del área de distribución de *Gentianella cosmantha*, revelaron que poblaciones con corolas rojizas poseen tamaño dentro del rango de variación señalado por Fabris para la f. *violacea*. Con respecto al color, es frecuente que al envejecer la flor, la corola vire de rojo a rojo-vinoso.

Gentianella magellanica (Gaudich.) Fabris ex D. M. Moore, Sci. Rep. Brit. Antarc. Surv. 60:103. 1968. BASÓNIMO: *Gentiana magellanica* Gaudich., Ann. Sci. Nat. (Paris) 5(1):102. 1825. TIPO: [ARGENTINA]: "Iles Malouines," *Gaudichaud s.n.*, (HOLOTIPO: B+; ISOTIPOS: P!, K n.v.).

Gentiana patagonica ß *darwinii* Griseb., Gen. sp. Gent. 237. 1839. TIPO: CHILE. "Ad fretum Magellanicum, Elizabeth Island," *Darwin s.n.* (HOLOTIPO: K!). **Syn. nov.**

Gentiana modesta Phil., Linnaea 29:109. 1858. TIPO: [CHILE]: "In insulis Chonos dictis ad altit., ca. 800 ped.s.m., 3 Feb 1837," *F. Fonck 130* (HOLOTIPO: SGO 053926!). **Syn. nov.**

Gentiana lactea Phil., Anales Univ. Chile 90:206. 1895. TIPO: [CHILE]. VALDIVIA: "Cordillera Pelada, 1889," *F. Philippi s.n.* (HOLOTIPO: SGO 053925!; ISOTIPO: BM!). **Syn. nov.**

Gentiana patagonica var. *gracilis* f. *pumila uniflora* Albov, Revista Mus. La Plata, Secc. Bot. 7:348. 1896. TIPO: [ARGENTINA]: "Vallèe de l'Olivaia, tourbières, 1896," *N. Albov 661 y 662* (SINTIPOS: LP!). **Syn. nov.**

Gentiana pearcei f. *nana* Hauman, Anales Soc. Ci. Argent. 86(3–4):299. 1918. SINTIPOS: [ARGENTINA. PROV. MENDOZA]: "Las Cuevas, Sep–Oct 1909," *M.S. Pennington 20* (BAF!); "Cordillère de Tunuyan, à 2700 metres," leg. *Sanzin 1301* (Herb. desconocido). **Syn. nov.**

Los caracteres utilizados por Grisebach para *Gentiana patagonica* ß *darwinii* (número de piezas de la corola) así como los empleados por Philippi para *Gentiana lactea* (grado de ramificación de los tallos, forma de las hojas e inflorescencias paucifloras) y los usados por Philippi, Albov y Hauman para *Gentiana modesta*, *Gentiana patagonica* var. *gracilis* f. *pumila uniflora* y *Genti-*

ana pearcei f. *nana* respectivamente (altura de la planta y número de flores), coinciden en un todo con los que definen a *Gentianella magellanica*.

Por otro lado, Spegazzini (1902) describió algunos taxones infravarietales de *Gentiana magellanica* (*G. magellanica* var. *darwinii* f. *cyanescens*; *G. magellanica* var. *darwinii* f. *albiflora*; *G. magellanica* var. *typica* f. *cyanescens*; *G. magellanica* var. *typica* f. *albiflora*) que coinciden con el rango de variación del color de la corola de *Gentianella magellanica*. Estos nombres subespecíficos carecen de toda validez taxonómica, ya que no se mencionan especímenes tipos ni ilustraciones.

Gentianella multicaulis (Gillies ex Griseb.) Fabris, Bol. Soc. Argent. Bot. 7:89. 1958.

BASÓNIMO: *Gentiana multicaulis* Gillies ex Griseb., Gen. sp. Gent. 225. 1839. TIPO: [ARGENTINA. MENDOZA]: "Habitat in humidis pr. Uspallata et pr. Manantiales del Portillo in Andibus Mendozianis, Fl. Jun.," *J. Gillies s.n.* (HOLOTIPO: K n.v.).

Gentianella achalensis (Gilg) T. N. Ho et S. W. Liu, Bull. Brit. Mus. (Nat. Hist.), Bot. 23(2):61. 1993. BASÓNIMO: *Gentiana achalensis* Hieron. ex Gilg, Bot. Jahrb. Syst. 22:322. 1896. TIPO: ARGENTINA. CÓRDOBA: San Miguel, en la Sierra Grande (Achala), 27 Mar 1875, *J.H.E.W. Hieronymus 215* (LECTOTIPO: CORD!). **Syn. nov.**

Gentianella mendocina (Gilg) J. S. Pringle, Sida 11:368. 1986. BASÓNIMO: *Gentiana mendocina* Gilg, Bot. Jahrb. Syst. 54, 2 (Beibl. 118):36. 1916. TIPO: ARGENTINA. MENDOZA: 1876, *R.A. Philippi s.n.* (HOLOTIPO: B+). **Syn. nov.**

Al igual que *G. magellanica*, *G. multicaulis* es una especie muy variable tanto en sus caracteres vegetativos como florales. El rango de variación se observa en el número, grosor y altura de los tallos, en la presencia y cantidad de hojas basales, en la cantidad de flores por inflorescencia y en el color de la corola. El lectotipo de *Gentiana achalensis* no difiere demasiado de *Gentianella multicaulis*. De igual manera, la diagnosis de *G. mendocina* se ajusta a dicha especie.

Gentianella ottonis (Phil.) Muñoz, Sinopsis Fl. Chile: 134. 1959. BASÓNIMO: *Gentiana ottonis* Phil., Linnaea 33:177. 1865. SINTIPOS: ARGENTINA. MENDOZA: "Portillo de los Puiquenes," *R.A. Philippi s.n.* (B+); CHILE: "Andes de Santiago," *R.A. Philippi s.n.* (SGO 053960!).

Gentiana ottonis var. *hexamera* (Phil.) Reiche, Fl. Chile 5:131.1907. BASÓNIMO: *Gentiana hexamera* Phil., Anales Univ. Chile 43:510. 1873. TIPO: CHILE: "Valle del Yeso de la Cordillera de Santiago, Ene 1861," *R.A. Philippi s.n.* (HOLOTIPO: SGO 053939!, 041974!; ISOTIPO: BAF!). **Syn. nov.**

Cuando Reiche (1907) subordina *G. hexamera* a nivel varietal de *G. ottonis*, señala que los caracteres de esta especie (tallos unifloros y flores 6–7-meras) podrían corresponder a un hecho tanto anómalo como frecuente. Si bien la mayoría de los ejemplares analizados de *G. ottonis* presentan flores pentámeras, las plantas de las dos cartulinas del holotipo y la del isotipo de *G. hexamera*, no dejan dudas de esta sinonimia por su hábito rizomatoso, el tamaño de las flores y la forma de los lóbulos corolinos.

ZYGOSTIGMA

Zygostigma australe (Cham. & Schltdl.) Griseb., Gen. sp. Gent. 150. 1839. BASÓNIMO: *Sabatia australe Cham. & Schltdl.*, Linnaea 1:194. 1826. TIPO: BRASIL: "Prov. Cisplatina, Braxuelo, Novembri mense floret.," *Sellow s.n.* (W?).

Gentiana rubra Larrañaga, Escritos de Don D.A. Larrañaga 2:100. 1923. TIPO: No citado. **Syn. nov.**

Tal como en el caso de *Gentiana flava*, Larrañaga describe e ilustra esta especie con bastante precisión, sin mencionar ejemplar de referencia, salvo su nombre vulgar y fecha de colección: "Canchalagua, Ener. 1811." En base al protólogo, no quedan dudas que se trata de *Zygostigma australe*.

Sobre la ampliación del área de distribución de *Chelonanthus viridiflorus* en América del sur.

Chelonanthus (Griseb.) Gilg es el género neotropical con mayor área de distribución de la tribu Helieae Gilg, extendiéndose desde el norte de México hasta el sur de Brasil y Bolivia; hasta el momento se aceptan ca. 8 especies (Struwe et al. 2002). Su taxonomía es muy confusa; en efecto, muchas de sus especies han sido descriptas o incluidas en distintos géneros tales como *Lisyanthus* Aublet (Don 1838; Grisebach 1839, 1845; Progel 1865, Bentham 1876), *Helia* Mart. (Kuntze 1891) e *Irlbachia* Mart. (Maas 1985; Pringle 1995). En la actualidad, algunas especies transferidas a *Irlbachia* (Maas 1985), han sido rehabilitadas a *Chelonanthus* (Struwe et al. 1998, 1999) por lo que su circunscripción no resulta fácil. Por otro lado, al no haber un tratamiento monográfico del género aún permanecen sin resolverse muchos problemas nomenclaturales y de circunscripción de taxones (Struwe et al. 2002).

En la Argentina, y como consecuencia de los cambios en la taxonomía de *Chelonanthus*, el registro de sus especies ha sido variable. En 1953, Fabris identificó como *C. grandiflorus* (Aubl.) Hassl., un único ejemplar proveniente del litoral (Prov. Misiones: *Molfino s.n.*). Hunziker (1984) puso en duda la existencia de esta especie en ese país debido a su escasa representatividad en los herbarios argentinos. Trabajos recientes registran la ocurrencia de *Irlbachia alata* (Aubl.) Maas en estudios polínicos de especies del litoral fluvial (Pire et al. 2004) e *I. alata* subsp. *viridiflora* (Mart.) Pers. & Maas en estudios florísticos de los esteros del Iberá, en Corrientes (Arbo & Tressens 2000). Al analizar los ejemplares de referencia y otras colecciones del nordeste de la Argentina, se pudo verificar que sólo *Chelonanthus viridiflorus* habita en este país; así, su área de distribución se extiende hacia el sur del continente.

En esta contribución se proporciona una detallada descripción y se ilustra *C. viridiflorus* a la par que se adicionan otras colecciones que reafirman la distribución de esta especie en territorio argentino y paraguayo.

1. Chelonanthus viridiflorus (Mart.) Gilg, en A. Engler u. K. Prantl, Nat. Pflanzenfam. 4(2):98. 1895. (**Fig. 3**). *Lisianthus viridiflorus* Mart., Nov. Gen. sp. pl. 2(2):94, t.173. 1827. *Helia viridiflora* (Mart.) Kuntze, Revis. gen. pl. 2:428. 1891. *Irlbachia alata* subsp. *viridiflora* (Mart.) Pers. & Maas, Proc. Kon. Ned. Akad. Wetensch., C 88(4):410. 1985. TIPO: "Crescit in subalpinis campis prope Villa Rica, Sabará, et alibi in Provincia Minarum" *Martius 772* (SINTIPO: M!).

Hierba anual. Tallo erecto, simple, terete en la base y subcuadrangular superiormente, de 65–100 cm alt. Hojas enteras, pinnatinervias, las inferiores

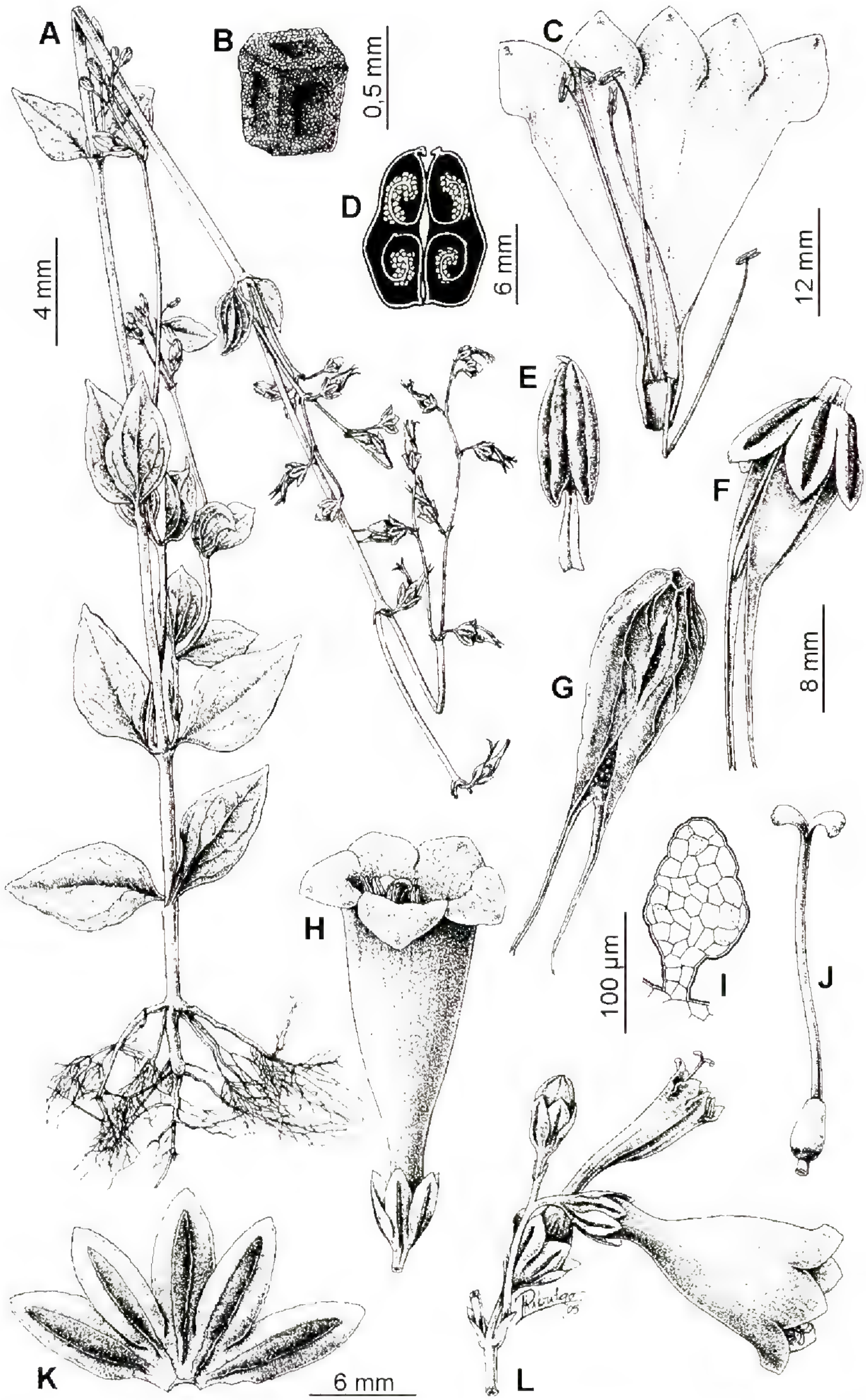


FIG. 3. *Chelonanthus viridiflorus*. **A.** Hábito. **B.** Semilla. **C.** Corola desplegada con estambres inclusos. **D.** Transcorte de ovario. **E.** Antera. **F.** Fruto con cáliz y estilo persistentes. **G.** Fruto en dehiscencia. **H.** Flor. **I.** Tricoma glandular del cáliz. **J.** Gineceo. **K.** Cáliz, vista externa mostrando las glándulas. **L.** Sector apical de inflorescencia. A, E–G de *Schinini et al. 11248*; B de *Arbo et al. 8492*; C, D, H–L de *Molfino s.n.* La escala de 12 mm vale para C, J, L; la de 6 mm para E, G, K; la de 8 mm para F, H.

brevemente pecioladas, subconnadas (las bases confluyen en una vaina membranosa), las superiores sésiles, lámina elíptica, aguda, base atenuada, de (1,5–)2,5–9 cm de long. × (0,6–)1,5–4,5 cm de lat., hipofilo con 2 ó 3 pares de nervios secundarios, opuestos y sobresalientes, pecíolo de 4,5–6 mm de long. Cimas dicotómicas terminales, por lo general paucifloras, cada rama con 2–6 flores, brácteas elípticas, agudas. Flores pentámeras, perfectas, levemente zigomorfas, horizontales, reflexas en post-antesis, cortamente pediceladas (5–7 mm); bractéolas escuamiformes, hasta ca.7 mm de long.; cáliz campanulado, persistente y poco acrescente, de 6–9 mm de long., tubo muy breve, con tricomas glandulares pluricelulares en la base, de 2–3 mm, lóbulos crasos, ovados, obtusos, por fuera y en el centro un área glandular elipsoidea sobresaliente; margen translúcido; corola verde pálida, de (2–)2,5–5 cm de long., tubo angosto en la base, ensanchado en campana ventricosa por arriba del cáliz, de (1,6–)2–4,4 cm de long., lóbulos ovados, rotundos, pentanervados, hasta unas 7 veces más cortos que el tubo, ápice grueso y oscuro, recurvado; estambres insertos debajo del 1/3 inferior del tubo, filamentos laminares subiguales, anteras ovoides o sagitadas, libres en su 1/3 basal, con un apéndice estéril en el ápice, polen en tétrades, blanco, abundante; gineceo bicarpelar, ovario claviforme, placentas introflexas, estilo filiforme, de igual longitud que los estambres, en post-antesis igual o más largo que la corola, estigma en dos lamelas ovadas. Cápsula septicida, reflexa, ovoide-cónica, rostrada (estilo persistente), dehiscente por el medio, en dos valvas al madurar. Semillas numerosas por fruto, anguladas, menores de 1 mm de diám.

Hábitat y distribución geográfica.—Especie característica de zonas pantanosas, sabanas húmedas, borde de ríos y embalsados. Habita en Venezuela, Colombia, Guyana, este de Bolivia (Dpto. Santa Cruz), centro y sudeste de Brasil (Edos. Mato Grosso, Goias, São Paulo), sudeste de Paraguay (Dptos. Alto Paraná, Caaguazú, Canendiyú, Itapuá y San Pedro) y noreste de Argentina (Provs. Corrientes y Misiones).

Material examinado: **ARGENTINA. Prov. Corrientes. Dpto. Ituzaingó:** Desembocadura del Arroyo Garapé en el Río Paraná, 45 km al E de Ituzaingó, en pantano, 24 Abr 1975, *Schinini et al. 11248* (CTES); **Dpto. Santo Tomé:** Reserva Natural Provincial del Iberá, Laguna Galarza, 28° 05' S, 56° 40' W, 0–100 m, embalsado al borde del canal de acceso a la Laguna, 25 Abr 1995, *Arbo et al. 6553* (CTES); Laguna de Luna, 28° 04' S, 56° 49' W, costa occidental, en embalsado, 24 Nov 1999, *Arbo et al. 8492* (CTES); Laguna Galarza y Luna, 03 Abr 1998, *Honfi & Daviña 00895* (MNES); Laguna Galarza, embalsado, 9 Dic 1974, *Quarín et al. 2509* (CTES). **Prov. Misiones. Dpto. San Javier:** San Javier, Feb 1922, *Molfino s.n.* (BAF). **PARAGUAY. Dpto. Caaguazú:** Yhú, 24 Ene 1951, *Sparre et Vervoorst* 2060 (CTES, LIL); 10 km al norte de Caaguazú, camino a Yhú, orilla de arroyo en terreno pantanoso, 8 Feb 1966, *Krapovickas et al. 12541* (CTES). **Dpto. Canendiyú:** Carpa-cué, pastizal sobre suelo saturado, 28 Mar 1996, *Jimenez & Marín 110* (CTES, PY); Ballinoti cué, cerrado, pastizal sobre suelo saturado, 19 Feb 1988, *Jimenez & Marín 2030BJ* (CTES). **Dpto. Itapuá:** Isla Yacyretá, pastizal que rodea al bosque de Arary, 22 Abr 1993, *Quintana et al. 265* (CTES, PY).

Sobre la presencia de *Schultesia guianensis* en Argentina y Paraguay

La cita de Fabris (1953) para *Schultesia guianensis* en la Argentina estaba documentada sólo por un ejemplar del Prof. J. Molfino s.n., procedente de Misiones. Se pudo localizar este ejemplar en el herbario BAF y corroborar que, efectivamente se trata de esta especie al compararlo con el material tipo depositado en París. En este trabajo, se describe e ilustra a esta especie y se la documenta además, para Paraguay.

Schultesia guianensis (Aubl.) Malme, Ark. Bot. 3(12):9. 1904. (**Fig. 4**). *Exacum guianensis* Aubl., Hist. pl. Guiane 1:68, t.26, f.1. 1775. TIPO: "Guiane" (P!).

Hierbas anuales, pequeñas, glabras, de 4–15 cm alt. Tallo erecto, tetrágono, con alas reducidas en los ángulos, poco ramificado superiormente. Hojas enteras, opuestas, las inferiores pseudopecioladas, espatuladas, obtusas, de 7–10 mm de long. × 5 mm de lat.; las superiores sésiles, elípticas, agudas, subconnadas en la base, de 10–25 mm de long. × 5–8 mm de lat. Flores solitarias o en cimas dicotómicas en el ápice de las ramas; brácteas elípticas, agudas. Flores tetrámeras, perfectas, sésiles o con pedicelos breves (hasta de 5 mm); cáliz urceolado, persistente, poco acrescente, de 12–19 mm de long., 4-alado, alas marcadamente retinervadas (1,5–2 mm de ancho), tubo de 8–11 mm, lóbulos subtriangulares largamente aleznados; corola rosada a purpúrea, marcescente, de 15–22 mm de long., tubo angosto en la garganta, de 9–12 mm, lóbulos obovados, rotundos, a veces apiculados, pentanervados, un poco más cortos que el tubo; estambres insertos en la 1/2 basal del tubo corolino, inclusos o apenas exertos, subiguales, sector libre de los filamentos alado hasta su altura media, alas irregularmente partidas en el ápice; anteras ovoides o sagitadas, libres en su 1/3 basal; polen en tétrades; gineceo bicarpelar, ovario elipsoide, un poco más corto que el tubo corolino, placentas introflexas, estilo filiforme, deciduo, estigma con dos lamelas trans-ovadas a subcirculares. Cápsula septicida, elipsoide. Semillas numerosas por fruto, subesféricas, ca 1 mm de diám.; episperma reticulado, células poligonales con paredes ligeramente onduladas.

Observación.—Acorde con Struwe et al. (1999) y Pringle (com. pers.), los especímenes procedentes de otras áreas de América muestran algunas diferencias con respecto a nuestros datos, sobre todo en la altura de la planta y la longitud del cáliz y la corola. Así, *Schultesia guianensis* en su conjunto, presenta un rango de variación más amplio en cuanto a los caracteres mencionados, extendiéndose la altura de la planta desde 3–45 cm, la longitud del cáliz de 8–22 mm y, la de la corola de 8–26 mm.

Hábitat y distribución geográfica.—Especie palustre de amplia distribución tropical y subtropical, que se extiende desde México hasta el noroeste de Argentina y Paraguay. En el Cono Sur habita en campos bajos y anegados en la ribera de cursos de agua y lagunas.

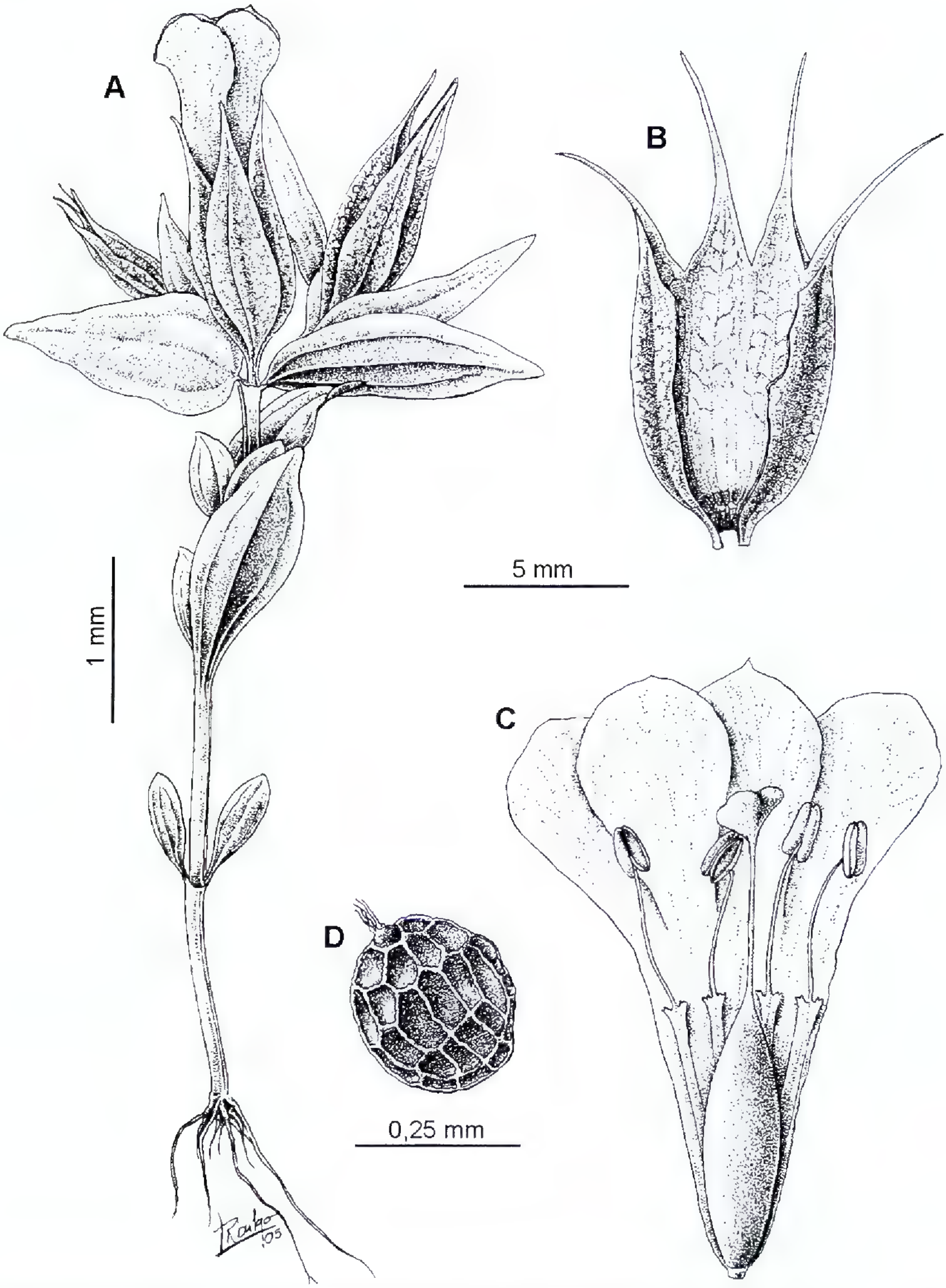


FIG. 4. *Schultesia guianensis*. **A.** Hábito. **B.** Cáliz abierto. **C.** Corola, androceo y gineceo. **D.** Semilla, con episperma reticulado. De *Molfino s.n.* (*BA 52976*). La escala de 5 mm vale para B, C.

Material examinado: **ARGENTINA. Prov. Misiones. Dpto. Capital:** Posadas a San José, Feb 1922, *Molfino s.n* (BA 52976); Posadas, hacia San José, en campo bajo, *Molfino s.n.*, Feb 1922, (BAF). **PARAGUAY. Dpto. Cordillera:** In regione lacus Ypacaray, 1913, *Hassler 12596* (BAF, LP); Camino de Altos a Loma Grande, 25° 17' S, 55° 15' O, 20 Mar 1989, *N. Soria* 3438 (FCQ); Cordillera, 25.08° S 57.12' W, 25 Febr 1990, *E. Zardini y R. Velázquez 19148* (AS). **BRASIL. Edo. Río de Janeiro:** Cabo Frío, Oct 1899, *E. Ule 4747* (CORD). **BOLIVIA. Dpto. Santa Cruz:** Fortín Ra-velo-Cerro San Miguel, Mar 1989, *F. Mereles 2744* (PY).

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Book Review

Olli Leeb. 2005?. **Coffee, cappuccino, espresso and much more**. (ISBN 3-921799-48-1, hbk.). Kochbuch-Verlag?, Munich. $30.00, 159 pp, 14 color illus., 6 3/4" × 8 3/8".

Robusta, arabica, peaberry, mocha...?

"Perfectly home made by Olli Leeb," follows the title of this charming homespun publication. A loosely edited translation from the German results in a quaint personal, across-the-table style of narrative. Add to that the typewriter styled, unjustified, courier font and simply drawn graphics (rendered only slightly out of artistic perspective) and you have a very fun book! And as an added anomaly, except for a few color graphics, the book is printed in an apropos light sepia tone. This is basically a coffee cookbook which the author makes no bones about. It does, however, begin with several one or two page "chapters" on various topics. He skims through such topics as cultivation, different varieties, processing, origins and movement around the globe, roasting, and even the origins of (gasp!) instant coffee. From these chapters he goes on to the preparation of the different styles of coffee drinks (cappuccino, Turkish, café latte etc.) and the use of coffee in other drinks. Finally, there are several chapters on food prepared with coffee including: cakes, ice cream, pastries, and other desserts. All is interspersed with comments on the role of coffee in history, politics, culture, and social custom.

By way of example here is one of my favorite quotes from the book: "The small coffee bean met its greatest success during the industrialization when beer, which until then had been consumed at work and even at breakfast, was gradually being pushed aside by coffee. This brought forth a more productive labor force, which was better protected when handling machinery and worked more efficiently." Regardless of depth of knowledge anyone interested in the bean will enjoy this delightful publication.—*Robert J. George, Botanical Research Institute of Texas, Fort Worth, TX 76102-4060, U.S.A. rgeorge@brit.org.*

AMELICHLOA: A NEW GENUS IN THE *STIPEAE* (POACEAE)

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ABSTRACT

A new genus of *Stipeae* (Poaceae), **Amelichloa**, is described. It differs from other genera in the tribe in the woody, sharp tips of it basal leaves, the presence of smooth longitudinal ribs on its caryopses, its persistent stylar bases and in the frequent presence of cleistogamous panicles in the axils of its basal leaf sheaths. There are five species in the genus: **A. ambigua**, **A. brachychaeta**, **A. brevipes**, **A. caudata**, and **A. clandestina**. The first four species are native to South America; **A. clandestina** is native to northern Mexico. A key to the species is provided. Three of them, *A. brachychaeta*, *A. caudata*, and *A. clandestina*, have become established in disturbed areas on other continents. The name honors Dr. María Amelia Torres.

RESUMEN

Se describe **Amelichloa,** un nuevo género para la tribu *Stipeae* (Poaceae). El mismo difiere de otros géneros de la tribu por presentar ápices de las hojas basales punzantes y muy resistentes; suaves lineas longitudinales en la superficie del cariopse y bases estilares persistentes, así como en la frecuente presencia de cleistógenos en las axilas de las hojas basales. El género se encuentra constituído por cinco especies: **A. ambigua**, **A. brachychaeta**, **A. brevipes**, **A. caudata** y **A. clandestina**. Las cuatro primeras nativas de Sudamérica; **A. clandestina** del norte de México. Se incluye una clave para especies. Tres de las especies *A. brachychaeta*, *A. caudata* y *A. clandestina* se han establecido en áreas disturbadas de otros continentes. Se dedica este género a la Dra. María Amelia Torres.

This paper arises from the need to determine the appropriate generic treatment of three grass species introduced in the United States. In traditional generic treatments they are known as *Stipa brachychaeta*, *S. caudata*, and *S. clandestina*. All three have names in *Achnatherum* (Barkworth 1993; Jacobs & Everett 1996). The first two have, in addition, names in *Jarava* (Peñailillo 2002). Soreng et al. (2003) treated *S. brachychaeta* and *S. caudata* as species of *Jarava* and *S. clandestina* as a species of *Achnatherum*.

We reviewed fresh material, herbarium samples and type specimens of all three species and became convinced that, not only do they all belong to the same genus, but that they do not belong to any currently recognized genus. In this paper, we present the new genus, explain how it differs from other American genera, list the species that it includes, and provide a key to the species.

Etymology.—We are naming the new genus *Amelichloa* in honor of Dr. María Amelia Torres who has generously shared with us her extensive knowledge of South American *Stipeae*.

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Amelichloa Arriaga & Barkworth, gen. nov. TYPE: *Amelichloa ambigua* (Speg.) Arriaga & Barkworth (*Stipa ambigua* Speg.).

Species Amelichloae differunt a speciebus generum aliorum Stipearum laminis apicibus rigidisimis et acutissimis, et caryopsidibus basibus stylorum persistentibus et paginis una dorsali et duobus costis lateralibus rasilibus et longitudinalibus, et saepius paniculis cleistogamis in axillis foliorum basalium quam inter species alias in tribu pro parte maxima.

Plants perennial, cespitose. **Culms** erect, with 2–3 nodes. **Leaves** mostly basal; **sheaths** open, smooth, glabrous; **auricles** absent; **ligules** scarious, rounded to acute; **blades** stiff, involute, apices very stiff, sharply pointed. **Inflorescences** paniculate, main panicle terminal, apparently wholly chasmogamous, reduced cleistogamous panicles often present axillary to the basal leaf sheaths. **Spikelets of terminal panicles** with 1 floret, disarticulating above the glumes and below the floret. **Glumes** exceeding the floret, acute to acuminate, 1–5-veined; **anthoecia** fusiform, terete; **calluses** antrorsely strigose, blunt; **lemmas** pubescent, often more densely and/or more persistently so over the midvein and lateral veins, hairs on the lower portion about 0.7–2 mm long, hairs on the distal portion often longer; **crown** not developed; **awns** 1–2-geniculate, scabrous, persistent; **lodicules** 3; **stamens** 3, anthers sometimes all of equal size and more than 2 mm long, sometimes 1 more than 2 mm long and 2 much shorter, sometimes all short; **ovaries** glabrous, style with 2 branches, united at the base, stigmas plumose. **Caryopses** fusiform, with 3 smooth, longitudinal ribs at maturity, stylar bases 1–2 mm long, persistent, sometimes eccentric; **hila** linear, about as long as the caryopses. **Spikelets of axillary panicles** 0.5–1 mm long, glumes thin, shorter than the florets, florets unawned or with reduced awns. $x = 11$?

Amelichloa includes five species, four of which are South American. The fifth species, *A. clandestina*, grows in northern Mexico. Some species have also become established in other parts of the world. The short anthers are probably associated with cleistogamy. A similar variation in anther length is also found in the primarily South American genus *Nassella*. In *N. leucotricha* (Trin. & Rupr.) R.W. Pohl, the proportion of florets with the different combinations varies in response to environmental conditions.

Cattle avoid the species of *Amelichloa* because of the pointed leaves. The frequent presence of cleistogenes also favors establishment of the species in areas that are grazed or mown. The combination of the sharp leaves and cleistogenes means that members of the genus could become serious problems in rangelands.

The only chromosome count that has been made for the genus is of $2n = 44$ for *Amelichloa brachychaeta* (Bowden and Senn 1962). None of the species has been included in any molecular studies. We shall be initiating a study that includes some species of *Amelichloa*, plus many other South American taxa, in summer, 2006.

1. Hairs at the top of the lemmas 4–5 mm long, numerous _____ **A. ambigua**
1. Hairs at the top of the lemmas up to 2.5 mm, long, sparse.
   2. Awns 27–30 mm; florets 7–9.8 mm _____ **A. brevipes**
   2. Awns 10–25 mm; florets 4–8 mm.
      3. Mature caryopses with inclined, eccentric stylar bases; lemmas glabrous between the midvein and the lateral vein, even at the base, usually also glabrous between the lateral vein and the marginal vein _____ **A. caudata**
      3. Mature caryopses with erect, usually centric stylar bases; lemmas pubescent between the lateral and marginal veins on the lower 1/2, usually also between the midvein and lateral veins.
         4. Florets 4–5.5 mm long; awns usually 1-geniculate _____ **A. brachychaeta**
         4. Florets 5.5–8 mm long; awns usually 2-geniculate _____ **A. clandestina**

Amelichloa ambigua (Speg.) Arriaga & Barkworth, comb. nov. BASIONYM: *Stipa ambigua* Speg., April 1925. Revista Argent. Bot. 1:27.

Jarava ambigua (Speg.) Peñailillo, Gayana, Bot. 59:30. 2002. TYPE: ARGENTINA: PROV. BUENOS AIRES: Pdo. Gral. Pinto, "in pratis circa Estación Iriate," 24 Nov 1905, *Spegazzini s.n.* (HOLOTYPE: LP ex LPS-2412!; ISOTYPE: BAA-2946 (col. Typus!)).

Stipa dusenii Hitchc., Contr. U.S. Natl. Herb. 24:271. 1925. TYPE: ARGENTINA: BUENOS AIRES: plains, Sierra de la Ventana., 29 Nov 1904, *P. Dusén s.n.* (HOLOTYPE: US-1161165; PARATYPE: BAA-3038 ex Herb. *Parodi 5054* (col. Typus!)).

Distribution.—Argentina and Uruguay (Rosengurtt et al. 1970; Zuloaga et al. 1994; Torres 1993, 1997), introduced to France (Verloove 2005).

Amelichloa brachychaeta (Godr.) Arriaga & Barkworth, comb. nov. BASIONYM: *Stipa brachychaeta* Godr., Mém. Sect. Sci. Acad. Sci. Montpellier 1:450. 1853.

Nassella brachychaeta (Godr.) Barkworth, Taxon 39:609. 1990. *Achnatherum brachychaetum* (Godr.) Barkworth, Phytologia 74:6. 1993. *Jarava brachychaeta* (Godr.) Peñailillo, Gayana, Bot. 59:30. 2002. TYPE: FRANCE: du Port Juvenal cultivé au Jardin Botanique, Patria ignota, "plantes etrangerse-an, Port Juvenal. *Anon. legit*, 22 May 1848 (HOLOTYPE (probable): MPU; OM: BAA-2979, hojas a & b! (col. typus, fragm. de un probable ejemplar tipo).

Stipa eminens fo. *viridis* Kuntze, Revis. Gen. Pl. 3:371. 1898. TYPE: ARGENTINA. SANTA FE: Ceres, Oct 1892, *Kuntze s.n.* (HOLOTYPE: NY; ISOTYPE: CORD; LP!).

Stipa lorentziana Griseb., Symb. Fl. Argent. 298–299. 1879. TYPE: ARGENTINA: Córdoba, *P.G. Lorentz* 46,187? (HOLOTYPE: GOET; ISOTYPE: CORD, US 866090! (fragm. ex GOET)).

Distribution.—Argentina, Chile, Perú and Uruguay (Matthei 1965; Rosengurtt et al. 1970; Zuloaga et al. 1994; Torres 1993, 1997). Although Tovar (1993) and Brako and Zarucchi (1993) do not mention it, the presence of this species in Perú is cited in Caro and Sánchez (1971), Torres (1997), and Verloove (2005). Introduced to the U.S.A., Australia (Jacobs & Everett 1993), France, and Spain (Verloove 2005).

Amelichloa brevipes (E. Desv.) Arriaga & Barkworth, comb. nov. BASIONYM: *Stipa brevipes* E. Desv., Fl. Chil. 6:282. 1854.

Jarava brevipes (E.Desv.) Peñailillo, Gayana, Bot. 59:30. 2002. TYPE: CHILE: en las provincias centrales de la República, *C. Gay 1106. s.d.* (HOLOTYPE: P; ISOTYPE: BAA! (col. typus fragm.), US 866138 (fragm.)).

Stipa hirtiflora Hack. in Dusén, Ark. Bot. 7:5, t.3, (f.7), t.7, (f. 4–5). 1908. TYPE: ARGENTINA. SANTA CRUZ: Arroyo Pelque, Jan 1905, *P. Dusén 5640* (HOLOTYPE: W; ISOTYPE: US 1161168, 3168627 (fragm.)).

Distribution.—Argentina (Roig in Correa 1978; Torres 1993; Zuloaga et al. 1994), Chile (Matthei 1965).

Amelichloa caudata (Trin.) Arriaga & Barkworth, comb. nov. BASIONYM: *Stipa caudata* Trin., Mém. Acad. Imp. Sci. St.-Pétersbourg, Sér. 6, Sci. Math. 1:75. 1830.

Achnatherum caudatum (Trin.) S.W.L. Jacobs & J. Everett, Telopea 6:582. 1996. *Jarava caudata* (Trin.) Peñailillo, Gayana, Bot. 59:30–31. 2002. TYPE: Specimena Chilensia, *J. Lindley s.n.* (HOLOTYPE: LE-TRIN 1392.01 (& fig.); ISOTYPE: BAA 3001! (col. typus fragm), US 2489479 (fragm)).

Stipa bertrandii Phil., Linnaea 33(3–4):283. 1864. TYPE: CHILE: Andes de Santiago, *Bertrand s.n.* (HOLOTYPE: SGO-PHIL-102; ISOTYPE: BAA 2972 ! (col. typus fragm. ex holotype), SGO 62787, 63156; US 866140).

Stipa amphicarpa Phil., Anales Mus Nac. Santiago de Chile 11, lam.3, f.2. 1892. TYPE: CHILE: prope Angol, Dec 1887, *R.A. Philippi* (HOLOTYPE: SGO-PHIL 99, BAA 2952 ! (col.typus fragmento ex SGO); ISOTYPE: SGO 37393, 62793, US A866145).

Stipa litoralis Phil., Anales Univ. Chile 93:717. 1896. TYPE: CHILE: Isla Quiriquina, Mar 1880, *R.A. Philippi s.n.* (HOLOTYPE: SGO 62798; US 825120 (fragm. ex SGO)).

Distribution.—Argentina, Chile and Uruguay (Matthei 1965; Rosengurtt et al. 1970; Zuloaga et al. 1994; Torres 1993, 1997); introduced to Australia (Jacobs & Everett 1993), England, Italy, Spain (Verloove 2005), and U.S.A.

Amelichloa clandestina (Hack.) Arriaga & Barkworth, comb. nov. BASIONYM: *Stipa clandestina* Hack., Repert. Spec. Nov. Regni Veg. 8:516. 1910.

Achnatherum clandestinum (Hack.) Barkworth, Phytologia 74:6. 1993. TYPE: MÉXICO: COAHUILA: Saltillo, Mar 1908, *Arsène 3441* (LECTOTYPE: W; ISOLECTOTYPE: MO 845904!; US 1030718, 3168628 (fragm. ex W). Lectotype designated by Hitchcock, Contr. U.S. Natl. Herb. 24:238. 1925.

Distribution.—México; introduced to U.S.A. Hitchcock (1925) included *Stipa pittieri* in *S. clandestina* and, as a result, included Colombia in the range of *S. clandestina*. The type of *S. pittieri* (US 531634!), however, belongs in *Nassella*, as is reflected in the combination *N. pittieri* (Hitchc.) Peñailillo (1998). Thus, it appears that *A. clandestina* is restricted to northern México.

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Book Notices

Flora of North America (Asteraceae)

Flora of North America Editorial Committee (Eds.) 2006. **Flora of North America North of Mexico. Vol. 19. Magnoliophyta: Asteridae, part 6: Asteraceae, part 1.** (ISBN 0-19-530563-9; 978-0-19-530563-0, hbk.). Oxford Univ. Press, 198 Madison Avenue, New York, NY 10016, U.S.A. (**Orders:** http://www.oup.com). $95.00, 579 pp., illustrations, maps, 8 1/2" × 11".

Flora of North America Editorial Committee (Eds.) 2006. **Flora of North America North of Mexico. Vol. 20. Magnoliophyta: Asteridae, part 7: Asteraceae, part 2.** (ISBN 0-19-530564-7; 978-0-19-530564-7, hbk.). Oxford Univ. Press, 198 Madison Avenue, New York, NY 10016, U.S.A. (**Orders:** http://www.oup.com). $95.00, 666 pp., illustrations, maps, 8 1/2" × 11".

Flora of North America Editorial Committee (Eds.) 2006. **Flora of North America North of Mexico. Vol. 21. Magnoliophyta: Asteridae, part 8: Asteraceae, part 3.** (ISBN 0-19-530564-4; 978-0-19-530565-4, hbk.). Oxford Univ. Press, 198 Madison Avenue, New York, NY 10016, U.S.A. (**Orders:** http://www.oup.com). $95.00, 616 pp., illustrations, maps, 8 1/2" × 11".

From FNA website.—Covering the Asteraceae, or Composite, family, the largest family in the Flora of North America area, these three volumes contain nearly 2,420 species classified in 418 genera and 14 tribes. More than 60% of the species are endemic to the flora region and almost 10% are known as introductions that have naturalized. Members of this family of higher plants can be found to flourish in many habitats. Sunflowers, daisies, goldenrods, sagebrush, asters, zinnias, arnicas, chamomile, chrysanthemums, marigolds, chicory, lettuce, coneflowers, ragweeds, tickseeds, thistles, dandelions, tarweeds, cockleburs, butterweeds, and many other familiar plants are members of the Asteraceae. Each of the genera within these volumes has one or more representative species illustrated with a line drawing; more than 660 species are illustrated. Occurrence maps for nearly 3,300 species and subspecies/varieties accompany the identification keys, descriptions, and discussions about these plants.

TAXONOMY OF THE *CUSCUTA PENTAGONA* COMPLEX (CONVOLVULACEAE) IN NORTH AMERICA

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ABSTRACT

Cuscuta pentagona, *C. campestris*, and *C. glabrior* are closely similar taxa recognized here at specific rank. Closely related to these are *C. runyonii*, *C. harperi*, *C. plattensis*, and *C. sandwichiana*, as well as *C. obtusiflora* var. *glandulosa* and *C. polygonorum*. *Cuscuta runyonii*, *C. harperi*, and *C. sandwichiana* are relatively narrow endemics, *C. plattensis* and *C. glabrior* have wider but apparently discrete ranges, while *C. obtusiflora* var. *glandulosa*, *C. polygonorum*, and especially *C. pentagona* and *C. campestris* are widespread and broadly sympatric in North America, at least in some regions. *Cuscuta campestris* is one of the most widespread species in the world, being additionally recorded from South America, Europe, Asia, Africa, and Australia. Comparisons among these nine species are presented as a key and as comparative descriptions. SEM images are provided for flowers, fruits, seeds, and pollen.

RESUMEN

Cuscuta pentagona, *C. campestris*, y *C. glabrior* son taxa fuertemente semejantes, reconocidos aquí como especies. Estrechamente relacionadas con éstas están *C. runyonii*, *C. harperi*, y *C. plattensis* así como también *C. obtusiflora* var. *glandulosa* y *C. polygonorum*. *Cuscuta runyonii*, *C. harperi* y *C. sandwichiana* son endémicas con áreas pequeñas, *C. plattensis* y *C. glabrior* tienen rangos geográficos más amplios pero aparentemente distintos, mientras que *C. obtusiflora* var. *glandulosa*, *C. polygonorum*, y especialmente *C. pentagona* y *C. campestris* son comunes y ampliamente simpátricas en Norteamérica, al menos en algunas regiones. *Cuscuta campestris* ocurre fuera de Norteamérica, siendo mencionada de Sudamérica, Europa, Asia, Africa, y Australia. Las comparaciones entre estos seis taxa se presentan en forma de clave y descripciones comparativas. Se ofrecen imágenes de SEM de las flores, frutos, semillas, y polen.

Engelmann (1859) distinguished three varieties of *Cuscuta pentagona* Engelm. in addition to the typical form: var. *calycina*, var. *verrucosa*, and var. *microcalyx*. Yuncker (1932, 1965) treated var. *calycina* and var. *verrucosa* at specific rank but provided a new name for each: *C. campestris* Yuncker (nom. nov.) and *C.*

glabrior (Engelm.) Yuncker (comb. nov.), respectively. He treated var. *microcalyx* as a synonym of typical *C. pentagona*. Recent studies have not recognized *C. campestris* at any rank (e.g., Beliz 1986; Gandhi et al. 1987), while *C. glabrior* has been regarded as a variety of *C. pentagona* (Gandhi et al. 1987) or as nomenclatural synonym of *C. indecora* Choisy var. *neuropetala* (Engelm.) Hitchc. (Beliz 1986). Three other species from North America, *C. harperi* Small, *C. plattensis* A. Nels., and *C. runyonii* Yuncker, were included by Yuncker in the same group (subsect. *Arvenses* Yuncker) with *C. pentagona* and *C. campestris* (Yuncker 1965). Although *C. runyonii* has been considered a good species by all authors, *C. harperi* and *C. plattensis* were treated by Beliz in her Ph.D. dissertation (1986) as nomenclatural synonyms of "*C. pentagona* var. *polygonorum*" and *C. indecora*, respectively.

The current paper is the second of several to present taxonomic analyses of *Cuscuta* species groups and complexes. The first (Costea et al. 2005) gave an assessment of *Cuscuta nevadensis* and *Cuscuta veatchii*; three others follow in this issue (Costea et al 2006a,b,c). Other two papers that are now in preparation will deal with the phylogeny of *Cuscuta* and its infrageneric taxonomy, including the formal delimitation of the groups of species treated in the four papers published in this issue. Evaluations of the status of all these taxa are necessary for the accounts of *Cuscuta* in the Flora of North America and the forthcoming revision of The Jepson Manual (California). The comments below on reproductive biology and taxonomy are in perspective of the whole genus.

REPRODUCTIVE BIOLOGY AND TAXONOMY OF *CUSCUTA*

Scarcity of information regarding the reproductive biology of *Cuscuta* species limits progress toward understanding the taxonomy and evolution of this genus. For example, a detailed study of floral biology is available only for *C. attenuata* Waterfall (Prather & Tyrl 1993), which is very closely related to to *C. indecora*. Although they may be sympatric over an extensive geographical range, species such as *C. campestris* and *C. pentagona* have never been found "growing together at the same site" (Musselman 1986). Apparently a single herbaceous host cannot support more than one parasite (often a single *Cuscuta* plant simultaneously parasitizes several different host plants), although it does not seem impossible that colonies of different *Cuscuta* species might exist side by side. Furthermore, although some species (e.g., *C. epithymum* Murray, *C. rostrata* Shuttlw. ex Engelm. & A.Gray) have been reported to be pollinated by insects (Beliz 1986; Musselman 1986; Holm et al. 1997), others such as *C. pentagona* and its relatives apparently are autogamous (Verdcourt 1948; Beliz 1986; Musselman 1986; Prather & Tyrl 1993; Dawson et al. 1994). In the *C. pentagona* complex, we observed that anthers dehisce longitudinally before flowers open, further substantiating previous observations of autogamy. The low pollen/ovule ratio (= 65) found by Beliz (1986) in *C. pentagona* (including *C.*

campestris) supports the idea that autogamy may be common (see Cruden 1977).

The occurrence of inbreeding may help explain the relatively high number of taxa (species and varieties) that are recognizable as morphological entities in *Cuscuta*. The existence of intermediate-like plants observed rarely in populations of the *C. pentagona* complex probably reflects populational variability in closely related taxa. Hybridization also is a possible explanation, but experimental attempts to produce hybrids (e.g. between *C. indecora* and *C. attenuata*) have failed (Prather & Tyrl 1993).

Seed dispersal of many *Cuscuta* species seems unspecialized (Kuijt 1969). "Natural" means of seed dispersal are unknown. Lyshede (1984) suggested that wind may play a significant role in dispersal because of the pits present on the seed coat of dry seeds. However, *Cuscuta* seeds do not possess "classical" adaptations for wind dispersal, and the alveolate/papillate seed coat seems more an adaptation related to the germination process (Costea & Tardif 2006). Kuijt (1969) mentioned that seeds remain viable while they pass through the digestive system of sheep, but Gómez (1994) in Sierra Nevada, Spain, reported that hosts infested with *C. epithymum* were avoided by the Spanish ibex, the main herbivore in the area. Herbivores may avoid plants infested with *Cuscuta* because of the yellowish color (Costea & Tardif 2006). Capsules and seeds of *Cuscuta* float, and although water dispersal has never clearly been documented, it may occur only in the species that prefer the vicinity of water, such as *C. gronovii* Willd. ex J. A. Schult. Dispersal over long distances of weed species such as *C. campestris* has been connected with anthropomorphic activities. The principal means of world-wide dispersal of *Cuscuta* weeds has been through contaminated seeds of forage legumes (alfalfa, clover, and lespedeza, especially *Lespedeza cuneata* (Dumont) G. Don; reviewed by Dawson et al. 1994; Costea & Tardif 2006). Furthermore, when wetted, the seed coat in *Cuscuta* species becomes papillose-gelatinous and adheres easily to soil particles, and seeds may thus be carried by farm machinery (Costea & Tardif 2006).

METHODS

Descriptions of morphology and micromorphology are based mostly on specimens from herbarium NY, which includes Yuncker's herbarium (Appendix 1). Measurements of floral parts except anthers were done on rehydrated herbarium material. Length of flowers was measured from the base of calyx to the tip of straightened corolla lobes. Pollen, anthers, seeds, and capsules were measured on SEM pictures taken with a scanning electron microscope Hitachi S-570 at 15 KV. Samples were coated with 30 nm gold using an Emitech K 550 sputter coater. Standard terminology for cell types and surface sculpturing patterns follows Barthlott et al. (1998); pollen terminology follows Hoen (1999). Conservation status was assessed using NatureServe (2005) ranks and criteria.

Identification of *Cuscuta* often is a lengthy process because rehydration of

flowers, dissection, and examination under a microscope are usually necessary. Variation may be expected on the same individual (e.g., Gandhi & Thomas 1983; Severova 1991). Furthermore, because flowers do not mature simultaneously, the size and ratios between different floral parts on the same plant may vary to some extent. A range of flowers, fruits, and seeds belonging to the same plant should be examined. The angled calyx of *C. pentagona* and *C. harperi* is best observed in flower and during early fructification; full development of capsules may obscure the character.

MICROMORPHOLOGY

Flowers and capsules.—Laticifers, **papillae**, and **multicellular protuberances** may occur on the floral parts and capsules and distinctions between these features can be important in recognizing members of the *C. pentagona* complex (magnification of 100× or more recommended). **Laticifers** are visible in the calyx and sometimes in the corolla and capsules of all taxa. Yuncker usually referred to them as "pellucid glandular-appearing cells" (Yuncker 1921, 1932, 1965). Laticifers may appear isolated, rotund, ovoidal or tangentially elongated, or they can be organized in rows (Fig. 1 c,e). Laticifers from the stems are perivascular, multinucleate, and articulated (Lyshede 1985). **Papillae** are more or less radially elongated cells, and they are present in the calyces, corollas, and capsules of *C. harperi*, *C. glabrior*, and *C. runyonii* (Fig. 1 e,f; 2 a,b,c). **Multicellular protuberances** are larger and they may occur in *C. runyonii* along the midveins of the calyx lobes (Fig. 2c). **Epicuticular wax** on the perianth, when present, is represented by longitudinally reticulated rodlets (Fig. 1f).

Pollen.—Pollen is relatively uniform among species. Grains are 3(–4)-zonocolpate (rarely 4–6 loxocolporate in aberrant grains), and they may be polymorphic in the same anther or flower, from spheroidal to prolate (Fig. 3). Ornamentation varies from tectum imperforatum or with a few puncta in *C. glabrior*, *C. runyonii*, and *C. plattensis*, to tectum perforatum in *C. pentagona*, *C. campestris*, *C. harperi*, and *C. obtusiflora* var. *glandulosa* (Fig. 3). The latter three species have sexine often persistent in punctum apertures (Fig. 3). *Cuscuta pentagona* and *C. obtusiflora* var. *glandulosa* have the largest puncta, up to 0.7 µm in diameter, sometimes approaching a microreticulate ornamentation (Fig. 3).

Seeds.—A striking feature of the seed coat epidermis is that when seeds dry, cells of the outer cell wall invaginate, which causes the seed surface to become alveolate (Fig. 4; see also Lyshede 1984; Knepper et al. 1990; Costea & Tardif 2006). Water uptake induces bulging of the invaginated epidermal walls, and epidermis cells become swollen and papillose (Fig. 4c). The diameter of seed coat epidermal cells is 17–50 µm in *C. pentagona*, *C. campestris*, *C. glabrior*, *C. runyonii*, and *C. harperi* and 15–20 µm in *C. plattensis*, *C. obtusiflora* var. *glandulosa*, and *C. polygonorum*. The seeds of *C. runyonii* and *C. polygonorum* have epicuticular wax organized as longitudinal rodlets (Fig. 4d), a feature not

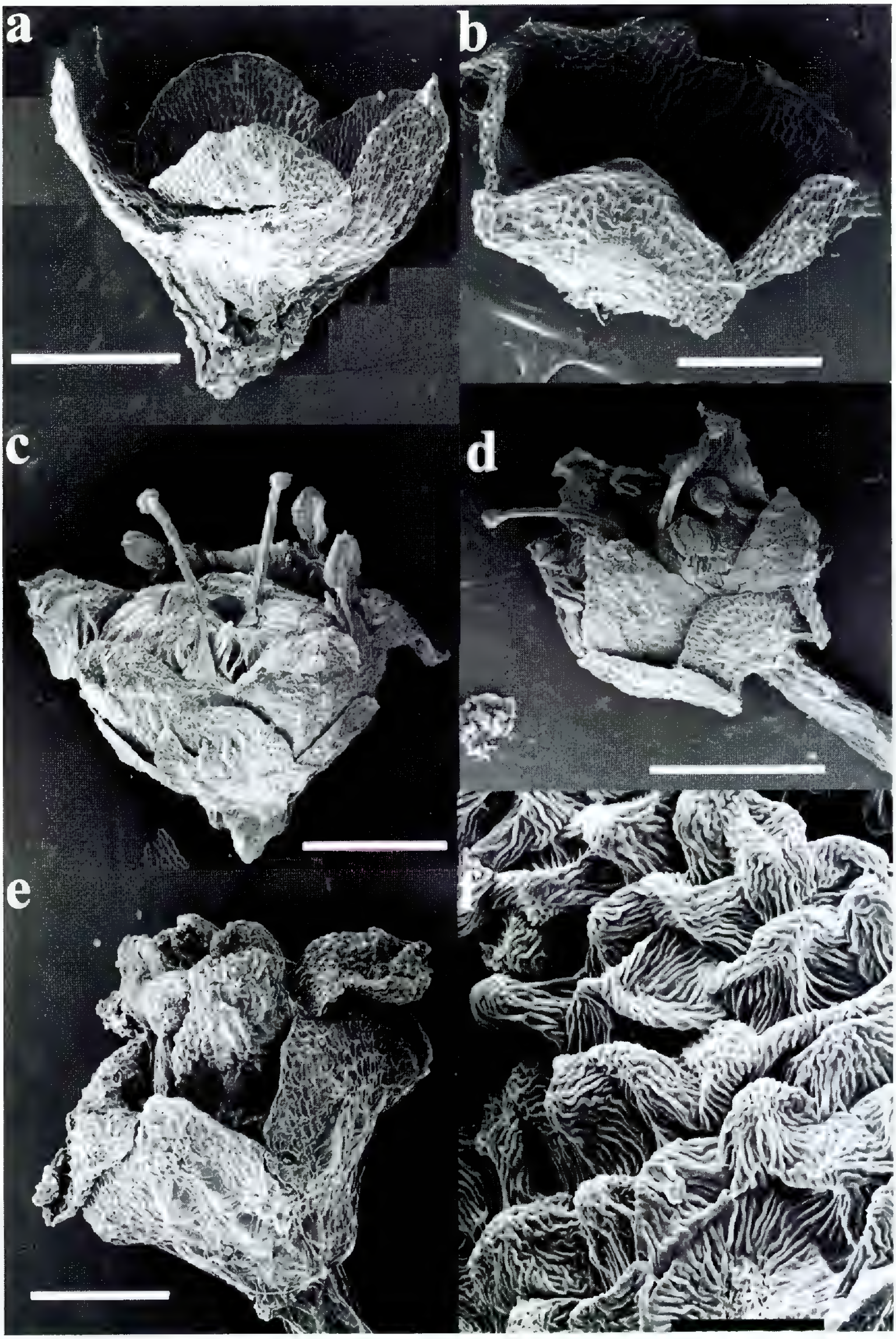


FIG. 1. **a.** Calyx of *C. campestris* (scale bar = 1 mm); **b.** Calyx of *C. pentagona* (scale bar = 0.5 mm); **c.** Flower with maturing capsule of *C. campestris* (scale bar =1 mm); **d.** Flower of *C. pentagona* (scale bar = 0.75 mm); **e.** Flower of *C. harperi* (scale bar = 0.5 mm); **f.** Papillae on the corolla lobes of *C. harperi* (scale bar = 0.43 μm).

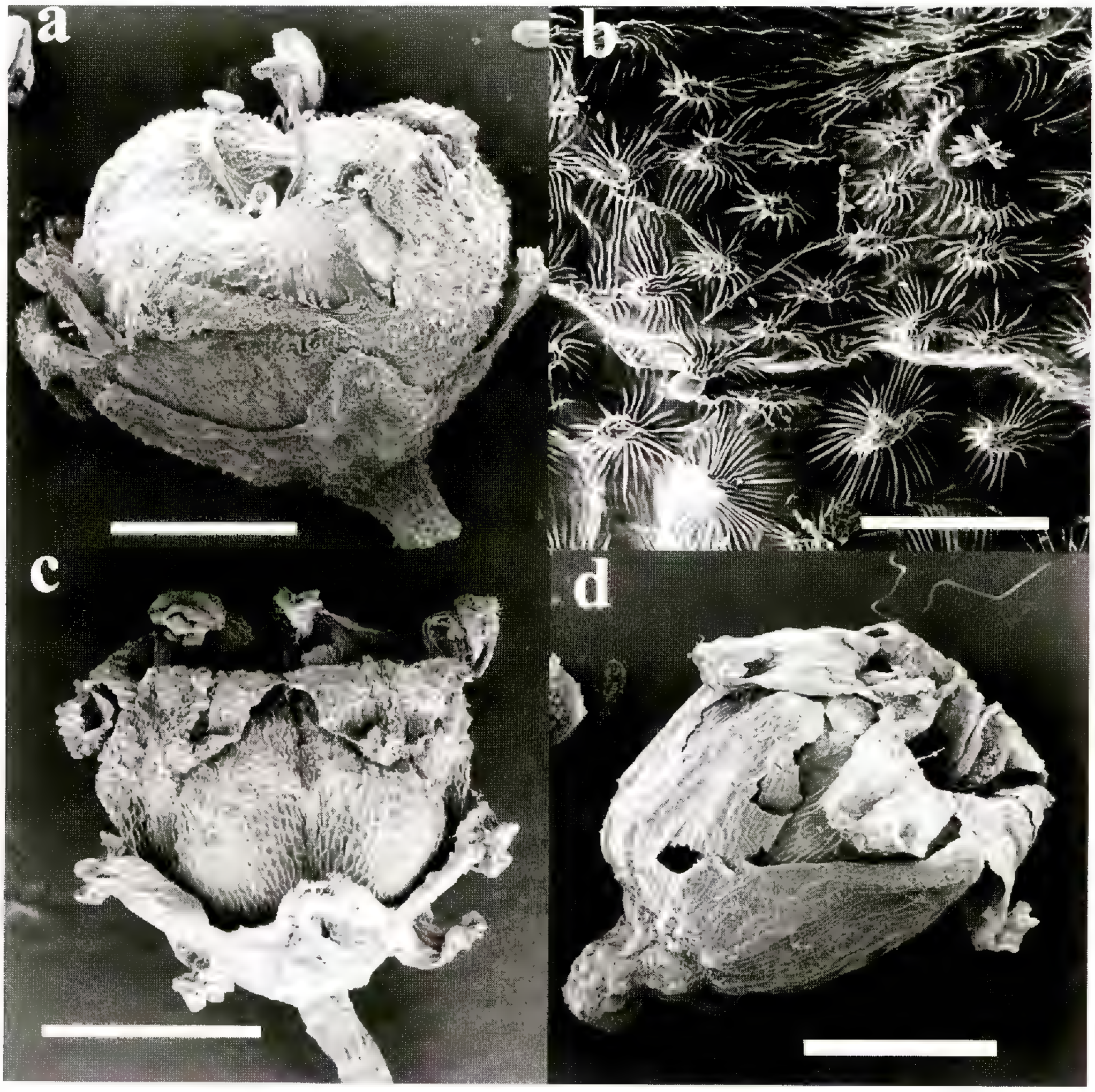


FIG. 2. **a.** Flower with maturing capsule of *C. glabrior* (scale bar = 1 mm); **b.** Papillae on the capsule of *C. glabrior* (scale bar = 0.75 µm); **c.** Flower of *C. runyonii*, arrows indicate multicellular projections; **d.** Flower of *C. plattenis* (scale bars = 1 mm).

observed in the other species. The hilum is round to broadly elliptic; the cells are smaller than in the rest of the seed coat and they are radially oriented around the vascular scar of the funiculum (Fig. 4 b,d). The vascular scar is linear, oblique to vertical (on broadest diameter of the seeds), 0.025–0.09 mm in *C. pentagona*, *C. campestris*, *C. glabrior*, *C. runyonii*, *C. harperi*, and *C. sandwichiana* and 0.125–0.25 mm in *C. plattensis*, *C. obtusiflora* var. *glandulosa*, and *C. polygonorum* (Fig. 4 a,e,f).

TAXONOMY

This group of species is characterized by globose or mostly depressed-globose capsules with relatively large interstylar apertures, which sometimes are thick-

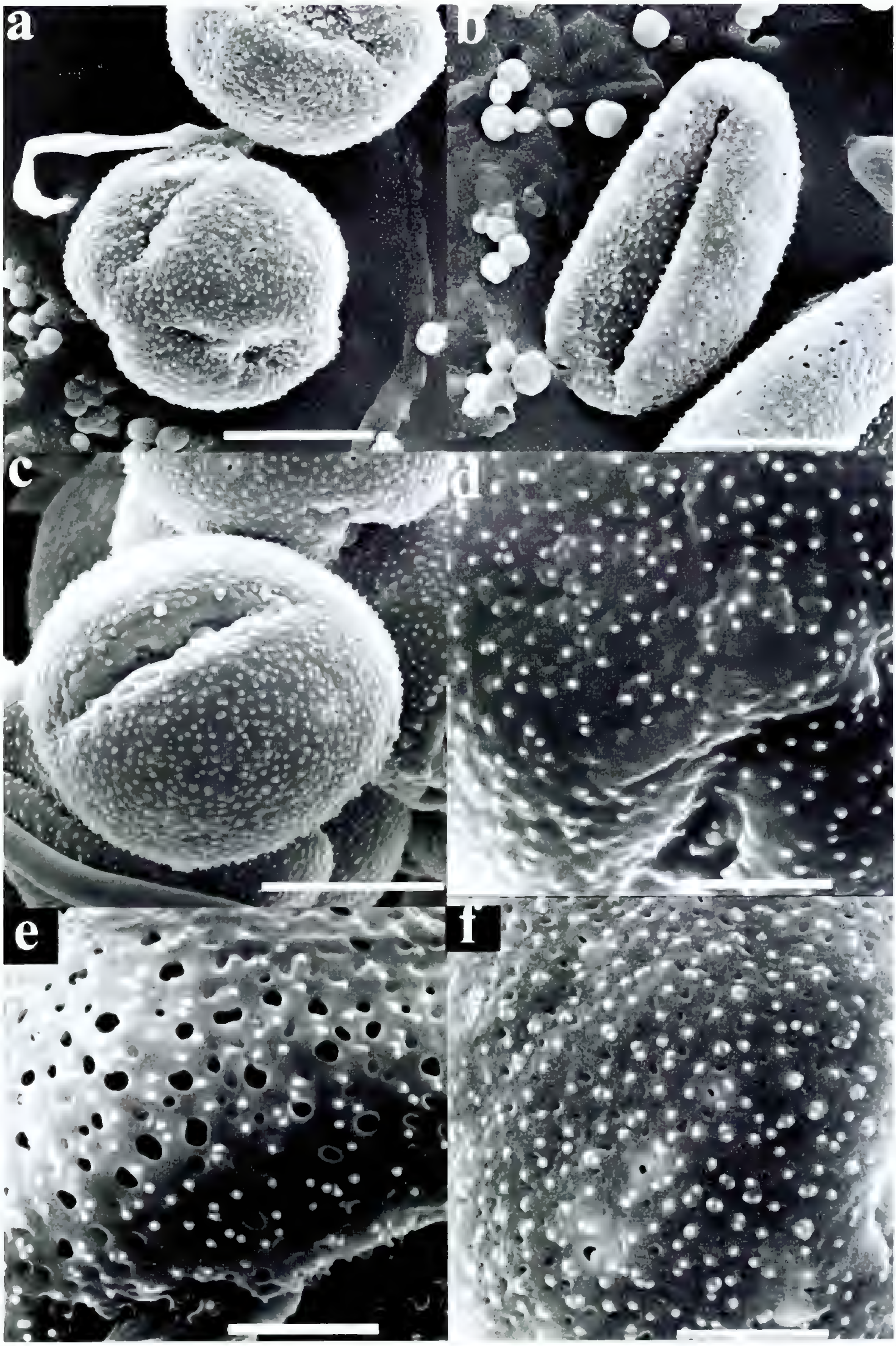


FIG. 3. Morphology of pollen. **a–b.** Polymorphic pollen grains of *C. harperi*; **c.** *C. plattensis* (scale bar = 8.6 μm); **d.** *C. plattensis*, tectum imperforatum; **e.** *C. pentagona*, tectum perforatum, **f.** *C. campestris*—tectum perforatum but sexine often persistent in puncta apertures (scale bars = 3 μm)

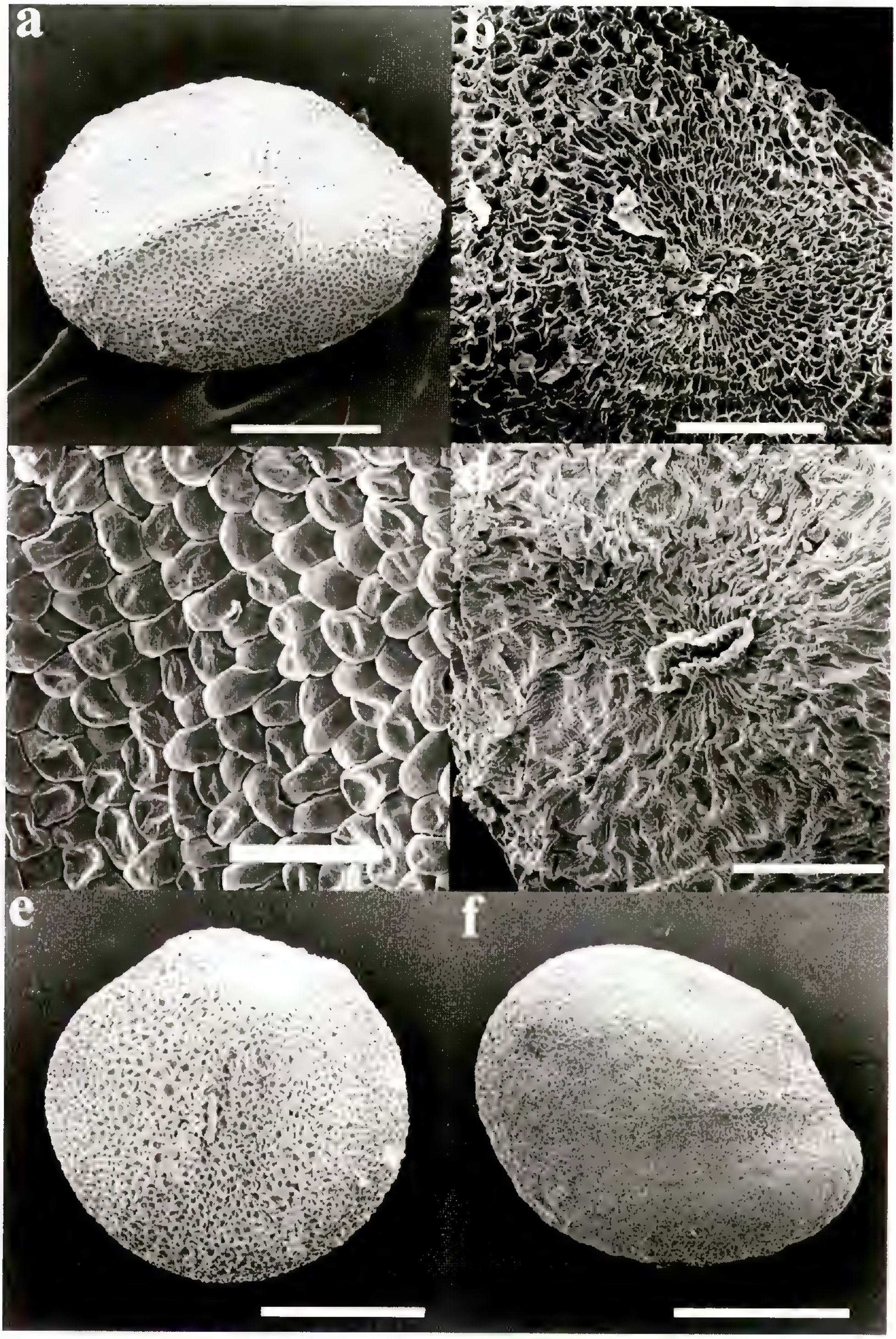


Fig. 4. Morphology of seeds. **a.** *C. campestris*, ventral view (scale bar = 0.5 mm); **b.** Hilum and alveolate seed coat of *C. campestris* (scale bar = 150 μm); **c.** Papillae on hydrated seed coat of *C. glabrior* (scale bar = 100 μm); **d.** Hilum of *C. runyonii* (scale bar = 120 μm); **e.** Seed of *C.* harperi, ventral view (scale bar = 0.43 mm); **f.** Seed of *C. plattensis*, ventral (scale bar = 0.5 mm).

ened but not raised to form a stylopodium. The corolla is persistent at the base of the capsules or surrounding them.

Cuscuta sandwichiana, a Hawaiian endemic, was placed by Yuncker (1932) in subsect. *Californicae* because it exhibits a reduction of the infrastaminal scales similar to the other species (*C. sandwichiana* was omitted in his 1965 treatment). This species, however, does not appear to be evolutionarily allied to *C. californica* complex. Beliz (1986) hypothesized that *C. sandwichiana* has evolved from *C. cephalanthi* Engelm., which is a member of the *C. gronovii* Willd. ex Roem. & Schult. complex. However, the stems of *C. sandwichiana* grow and branch as in species of the *C. pentagona* complex: the main and secondary stems grow continuously and never twine around the host. Instead, tendril-like branches produced from axillary buds of the rudimentary leaf-scales fix the parasite to the host. In *C. gronovii* and its relatives (e.g., *C. cephalanthi*, *C. umbrosa* Beyr. ex Hook., and *C. rostrata* Shuttlw. ex Engelm. & A. Gray), haustoria are formed as the main stem twines around the host, and no tendril-like axillary branches are generated (as first observed by Dawson 1984 in *C. gronovii*). The calyx and corolla of *C. sandwichiana* are relatively similar in morphology to those of *C. campestris*, although flowers are larger in *C. sandwichiana*. Seeds of *C. sandwichiana* are commonly angled, like those of *C. campestris*, and not dorsoventrally compressed as in *C. cephalanthi*.

Contrary to some relatively recent treatments (e.g. Austin 1986; Musselman 1986), *C. campestris* has not been accepted as a distinct taxon in modern North American overviews of the genus (Beliz 1986; Gandhi et al. 1987; Kartesz et al. 1999; USDA NRCS 2004). This judgment has been based on the allegedly variable morphology of the calyx, which was the main character used by Yuncker to differentiate this taxon from *C. pentagona* s. str. Beliz (1986) wrote: "The angled calyx (of *C. pentagona* s. str.) is not a constant feature, it is present in some flowers and absent on others in an individual; ... this feature may be an artifact created when flowers dry out." In contrast, we have found the angled calyx of *C. pentagona* to be a remarkably constant feature (Fig. 1b). Because the calyx lobes of *C. campestris* are overlapping, the calyx sometimes may appear angled in pressed flowers, but if the flowers are hydrated, the calyx usually appears "rounded" (Fig. 1a). The prominent angles of the calyx in *C. pentagona* are the result of a different morphology of the calyx lobes (Fig.1b). Furthermore, small but consistent differences in the size of floral parts, pollen, capsules, and seeds (see key below) usually separate the two taxa. Size overlap between the two taxa does occur, as well as intermediate-like plants, although the latter are uncommon. Austin (1979) discussed methods of pressing to avoid obscuring calyx traits in all species, but particularly in *C. pentagona* and *C. campestris*.

Four years before Yuncker formally recognized *Cuscuta campestris* as a separate species from *C. pentagona*, he was aware that his taxonomic solution might be received with reluctance. In a letter addressed to W.C. Ferguson, accom-

panying a collection of *C. campestris* sent to him for identification (*Ferguson 7795*, NY), Yuncker (1929) wrote: "I suspect I will be accused of various bad tendencies in the way of species making, but I think I have clarified the 'arvensis' situation somewhat." The assessment presented here also finds that *C. campestris* is consistently distinct from *C. pentagona*, although differences may seem subtle, and we believe their recognition as species best reflects the biological situation.

Similarly, *Cuscuta campestris* may be sometimes difficult to distinguish from *C. glabrior*, but the two taxa can be usually differentiated using a combination of features indicated in the key and descriptions. *Cuscuta runyonii* is most similar to *C. glabrior*, and *C. harperi* to *C. pentagona* (see descriptions; Yuncker 1932; 1942). *Cuscuta plattensis* does not appear to be evolutionarily allied to *C. indecora*, in contrast to the suggestion by Beliz (1986). Yuncker (1932, p. 140) considered *C. plattensis* to be "very closely related" to *C. campestris*. The morphology of seeds of *C. indecora* is different from the species of *C. pentagona* complex and more similar to that of *C. gronovii* and its relatives.

Two North American taxa previously treated within *Cuscuta* subsect. Platycarpae (Yuncker 1932), *C. obtusiflora* var. *glandulosa* Engelm. and *C. polygonorum* Engelm., are included here in subsect. *Arvenses* on the basis of their overall morphological similarity with the other species of this subsection. This close relationship was also emphasized by Beliz (1986), who referred to *C. polygonorum* as "*C. pentagona* var. *polygonorum*," within which *C. harperi* was included as a synonym. In contrast, we found that although *C. polygonorum* and *C. obtusiflora* var. *glandulosa* apparently are related to the species of subsect. *Arvenses*, each is clearly delimited morphologically. *Cuscuta australis* R. Br. from Australia and Asia, which is known only from one collection in North America (Jefferson Co., New York, 1926, *Muenscher s.n.*, NY), probably belongs to this group of species as well. This latter species has not been included in this taxonomic treatment limited in scope to North America.

In the *Cuscuta pentagona* complex, there are three relatively narrow endemics (*C. runyonii*, *C. harperi*, and *C. sandwichiana*), two with wider but apparently discrete ranges (*C. plattensis* and *C. glabrior*), and four species (*C. pentagona*, *C. campestris*, *C. polygonorum*, and *C. obtusiflora* var. *glandulosa*) widely distributed and broadly sympatric, at least in some regions. The exact North American distributions of *C. campestris* and *C. pentagona*, particularly, require additional floristic study. For additional synonymy see Yuncker (1932, 1965).

KEY TO SPECIES OF THE *CUSCUTA PENTAGONA* COMPLEX IN NORTH AMERICA

1. Infrastaminal scales well-developed, densely fringed or fimbriate.
   2. Corolla lobes obtuse, straight _____ **8. C. obtusiflora** var. **glandulosa**
   2. Corolla lobes acute, inflexed at apices.
      3. Calyx angled, loose around the corolla tube, 0.3 1.1 mm long; lobes broadly-ovate rhombic, ± auriculate, overlapping and forming prominent angles at

sinuses; flowers 0.9–2.5 mm long, corolla tube 0.5–1.2 mm; anthers 0.2–0.35 mm long; capsules 1.9–2.4 × 1.2–2.5 mm.

4. Flowers commonly 5-merous, 1.4–2.1(–2.5) mm long; calyx lobes not carinate and without rows of prominent laticifers along midveins (Fig. 1 b, d); seeds usually 4 per capsule, angled, subrotund to broadly elliptic, longitudinal groove absent _____ **1. C. pentagona**

4. Flowers commonly 4-merous, 0.9–1.1(–1.5) mm long; calyx lobes carinate or with rows of prominent laticifers along midveins (Fig. 1e); seeds usually 1 per capsule, almost spherical, with a longitudinal groove on the ventral face (Fig. 4e) _____ **2. C. harperi**

3. Calyx rounded, closely enclosing the corolla tube, 1–2.1 mm long; lobes ovate-triangular to triangular, not auriculate, overlapping or not and not forming prominent angles at sinuses; flowers 2.1–4.6(–5) mm long, corolla tube 1.1–2.5 mm; anthers 0.4–0.7 mm long; capsules 1.3–2.8 × 1.9–3.8 mm.

5. Calyx lobes about as wide as long, evidently overlapping (Fig.1a); persistent corolla enveloping 1/3 or less of the capsule (the basal portion) (Fig. 1c). _____ **3. C. campestris**

5. Calyx lobes longer than wide, not overlapping or only slightly so; persistent corolla enveloping 1/2 or more of the capsule.

6. Flowers (whole flowers or sometimes not obvious in the calyx) and capsules papillate; reddish-brown when dried, corolla campanulate-globose, saccate between the lines of stamen attachments; infrastaminal scales equaling corolla tube; seeds angled.

7. Calyx without multicellular projections (Fig. 2a) _____ **4. C. glabrior**

7. Base of calyx corresponding to each lobe with a reflexed spur-like multicellular projection 0.1–0.6 mm long, and often with smaller multicellular projections on the midveins of calyx lobes (Fig. 2c) _____ **5. C. runyonii**

6. Flowers (calyx, corolla, ovary) and capsules not papillate, creamy white when dried; corolla tube narrowly campanulate to cylindric-campanulate, not saccate between the lines of stamen attachments (Fig. 2d); infrastaminal scales shorter than corolla tube; seeds dorsoventrally compressed (Fig. 4f) _____ **6. C. plattensis**

1. Infrastaminal scales absent or reduced, bifid, or with a few distal teeth or fimbriae.

8. Flowers (4–)5-merous, 3–4(–5) mm; infrastaminal scales absent or reduced, truncate or triangular, bifid or distally with a few teeth or fimbriae; endemic to Hawaii _____ **7. C. sandwichiana**

8. Flowers (3–)4-merous, 2–2.7 mm; infrastaminal scales oblong, mostly shallowly bifid with 1–3 fimbriae on each side of the filament attachment or a few irregular fimbriae at the apex; widespread distribution in N America _____ **9. C. polygonorum**

1. **Cuscuta pentagona** Engelm., Amer. J. Sci. Arts 43:340. 1842. *Cuscuta arvensis* Beyr. ex Engelm. var. *pentagona* (Engelm.) Engelm., Trans. Acad. Sci. St. Louis 1:494. 1859. LECTOTYPE (Yuncker 1932): U.S.A. VIRGINIA: Norfolk, "On *Euphorbia* or *Tragia*," 1849, *Rugel s.n.* (MO).

Cuscuta pentagona Engelm. var. *microcalyx* Engelm., Amer. J. Sci. 45:76. 1843. LECTOTYPE (Yuncker 1921): U.S.A. ILLINOIS. [Cass Co.]: Beardstown, 1842, *Geyer s.n.* (MO). Engelmann cited only "Illinois."

Cuscuta arvensis Beyr. ex Engelm. in A. Gray, Man. Bot. (ed. 2) 336. 1856. *Epithymum arvense* (Beyr. ex Engelm.) Niewl. & Lunell, Amer. Midl. Naturalist 4:511. 1916. TYPE: Engelmann cited only "(in herb. Berlin)," perhaps referring to a Beyrich collection. As noted by Yuncker (1921, p. 51), a MO collection by Beyrich in 1845 from North Carolina may be "the type?" (an isotype). Evidently

Engelmann intended *C. arvensis* as a broad concept, since he noted that variants might be identified as *C. pentagona*, *C. pentagona* var. *microcalyx*, *C. pentagona* var. *calycina*, or *C. verrucosa*.

Stems 1.4–2.1(–2.5) mm in diameter, yellow to orange. **Inflorescences** dense, corymbiform to glomerulate of 3–15(–20) flowers; pedicels 0.5–3(–4.5) mm; bracts 1 at the base of clusters and 0–1 at the base of pedicels, 0.4–2.2 × 0.2–1.3 mm, membranous, ovate, ovate-triangular to lanceolate, margins entire, apex acute. **Flowers** (4–)5-merous, 1.4–2.1(–2.5) mm (Fig. 1d), membranous, whitish when fresh, yellowish to brown when dried; **papillae** sometimes present on the corolla lobes; **laticifers** evident in the calyx and less obvious in the corolla and ovary/capsule, isolated or arranged in rows, ovoid or elongated; **calyx** yellow to brown, ± reticulate, shiny or not, angled, cupulate, ca. as long as the corolla tube, divided 1/2–2/3 the length, lobes overlapping and forming prominent angles at sinuses, broadly-ovate to rhombic, auriculate, not carinate, margins entire, apex rounded (Fig. 1b); **corolla** persistent; tube campanulate, 0.7–1.2 mm, not saccate between the lines of stamen attachments; lobes spreading, 0.65–1.1 mm long, triangular-lanceolate, margins entire, apex acute to acuminate, inflexed; **stamens** exserted, shorter than corolla lobes, anthers subrotund to broadly elliptic, 0.25–0.30 × 0.20–0.28 mm, filaments 0.3–0.4 mm; **pollen grains** 18–25.2 µm long; tectum perforatum; maximum diameter of puncta 0.6 µm; supratectal process granular to conical ± uniformly distributed (Fig. 3e); **infrastaminal scales** equaling corolla tube, oblong-ovate, rounded, ± uniformly, dense fimbriate; styles evenly filiform, 0.7–1.1 mm, ca. as long as the ovary; stigmas capitate, globose. **Capsules** indehiscent to irregularly dehiscent, globose-depressed to ovoid, 1.9–2.4 × 1.6–2.5 mm, not thickened or raised around the medium to large interstylar aperture, translucent or not, persistent corolla at the capsule base. **Seeds** 4 per capsule, angled, subrotund to broadly elliptic, 0.9–1.1 × 0.8–1 mm, seed coat cells reticulate to alveolate/papillate, 18–35 µm in diameter; epicuticular wax absent; hilum region round 0.4–0.5 mm in diameter, vascular scar 0.07–0.09 mm long, vertical to slightly oblique. ***2n*** **=** 56 (Fogelberg 1938), ca. 44 (Pazy & Plitmann 1995).

Distribution and ecology.—**CANADA:** Manitoba (based on only 2 collections from DAO and MTMG, respectively). **U.S.A.:** Alabama, Arkansas, D.C., Delaware, Florida, Georgia, Kansas, Illinois, Indiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, New Jersey, New York, North Carolina, North Dakota, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, Washington. We have seen no evidence that *C. pentagona* has spread outside of North America, where it is less common than *C. campestris*. Isolated European records identified as this taxon (e.g., Buia 1938) are instead *C. campestris*. Flowering Jun–Nov. **Hosts:** numerous hosts (Gaertner 1950) growing in a wide variety of climates and soil types.

Conservation status.—G4G5 (apparently secure to secure) (G5, NatureServe 2005).

2. Cuscuta harperi Small, Fl. S.E. U.S. ed. 2, 1361, 1375. 1913. TYPE: U.S.A. GEORGIA: Altamaha Grit, between Peacocks and Harrison, on *Chondrophora virgata*, 20 Jul 1906, *Harper s.n.* (HOLOTYPE: NY, see Yuncker 1943; ISOTYPE: NY).

Stems 0.15–0.3 mm in diameter, orange-yellow. **Inflorescences** loose, corymbiform of 2–10(–15) subsessile or short pedicellate flowers; pedicels 0.5–2.5(–3) mm; bracts 1 at the base of clusters and absent (rarely present) at the base of pedicels, like those of *C. pentagona*. **Flowers** 4(–5)-merous, 0.9–1.1(–1.5) mm (Fig. 1e), fleshy, creamy-white when fresh, yellow to brownish when dried; **papillae** present on the corolla lobes (Fig. 1f); **laticifers** evident along midveins of calyx and less obvious in the corolla and ovary/capsule, isolated or in rows, elongated; **calyx** yellow-brownish, ± reticulate, rarely shiny, about as long as the corolla tube, angled, cupulate, lobes basally overlapping and forming prominent angles at sinuses, broadly-ovate rhombic, ± auriculate, ± carinate or with laticifers along midveins, margins entire, apex rounded; **corolla** persistent; tube campanulate, not saccate, 0.5–0.7 mm; lobes erect to reflexed, 0.4–0.7 mm, triangular-ovate, margins entire, apex subacute to acute, inflexed; **stamens** exserted, slightly shorter than corolla lobes, anthers subrotund to broadly elliptic, 0.2–0.25 × 0.15–0.18 mm, filaments 0.16–0.25 mm; **pollen** grains 17.5–25 µm long; tectum perforatum but sexine often persistent in puncta aperture; diameter of puncta 0.4 µm; supratectal process granular granular to conical ± uniformly distributed (Fig. 3 a,b); **infrastaminal scales** as long as the corolla tube, narrowly oblong, rounded, shortly and irregularly-dense fringed in the distal half; styles uniformly narrow terete to filiform, 0.5–0.9 mm, shorter than the ovary; stigmas capitate, globose. **Capsules** indehiscent to irregularly dehiscent, globose to ovoid, 1.2–2.3 × 1.2–1.6 mm; not thickened around the small to moderately large interstylar aperture, almost translucent, with persistent corolla enveloping the 1/4–1/3 of the capsule bases. **Seeds** usually 1–2 per capsule, subglobose, with a longitudinal groove on the ventral face, 0.92–1.11 × 0.85–1.1 mm, seed coat cells alveolate/papillate, 35–50 µm in diameter; epicuticular wax absent; hilum region terminal, round, 0.14–0.16 mm in diameter, vascular scar 0.025–0.03 mm long, vertical to slightly oblique. ***2n*** = ?

Distribution and ecology.—**U.S.A.:** Alabama and Georgia. Flowering Sep–Nov. **Hosts:** *Bigelowia nuttallii*, *Croton willdenowii*, *Helianthus longifolius*, *Hypericum gentianoides*, *Liatris microcephala*, and other species of sandstone outcrops (see also Yuncker 1943).

Conservation status.—G1G2 (critically imperiled to imperiled) (G2, NatureServe 2005).

3. Cuscuta campestris Yuncker [nom. nov.], Mem. Torrey Bot. Club 18:138. 1932. Based on *Cuscuta pentagona* Engelm. var. *calycina* Engelm., Amer. J. Sci. 45:76. 1843 [1845]. *Cuscuta arvensis* Beyr. ex Engelm. var. *calycina* (Engelm.) Engelm., Trans. Acad. Sci. St. Louis 1:495. 1859. LECTOTYPE (Yuncker 1921): U.S.A. TEXAS: wet prairies, [no date], *Lindheimer 126* (MO).

Stems 0.3–0.5 mm in diameter, yellow to orange. **Inflorescences** dense,

corymbiform or glomerulate of (3–)6–25(–30) subsessile to short pedicellate flowers; pedicels 0.3–2.5(–3.5) mm; bracts 1 at the base of clusters and 0–1 at the base of pedicels, like those of *C. pentagona*. **Flowers** (4–)5-merous, (1.9–)2.1–3.6 mm (Fig. 1c), membranous, white-creamy when fresh, creamy or golden-yellow when dried; **papillae** absent; **laticifers** evident in the calyx and less obvious in the corolla and ovary/capsule, isolated or arranged in rows, rotund, ovoid or elongated; **calyx** yellow, reticulate, shiny, rarely obscurely angled, cupulate, about as long as corolla tube, divided 2/5–3/5 the length; lobes overlapping but not forming or rarely forming obscure angles at sinuses; ovate triangular, not carinate, margins entire, apex obtuse to rounded (Fig. 1a); **corolla** persistent; tube campanulate, not saccate, (1.1–)1.5–1.9 mm; lobes spreading, triangular-lanceolate, (1.1–)1.4–1.75 mm long, margins entire, apex acute to acuminate, inflexed; **stamens** exserted, shorter than corolla lobes, anthers broadly elliptic, (0.3–)0.4–0.5 × 0.25–0.3 mm, filaments 0.4–0.7 mm long; **pollen grains** 18.5–28 µm long; tectum perforatum but sexine often persistent in puncta aperture; maximum diameter of puncta 0.4 µm; supratectal process granular, often in groups of 2–4 (Fig. 3f); **infrastaminal scales** equaling or slightly exceeding corolla tube, oblong-ovate to spathulate, rounded, uniformly dense fimbriate; styles evenly filiform, 0.8–1.6 mm, ca. as long as the ovary; stigmas capitate, globose. **Capsules** indehiscent to irregularly dehiscent, globose-depressed to depressed, 1.3–2.8 × 1.9–3.8 mm; not thickened or raised around the large interstylar aperture, sometimes translucent, persistent corolla enveloping 1/3 or less of the capsule base. **Seeds** 4 per capsule, angled, subrotund to broadly elliptic, 1.12–1.54 × 0.9–1.1 mm, seed coat cells alveolate/papillate, 32–40 µm in diameter; epicuticular wax absent; hilum region subterminal, round, 0.45–0.5 mm in diameter, vascular scar, 0.085–0.01 mm long, vertical or slightly oblique (Fig. 4 a,b). ***2n*** **=** 56 (Fogelberg 1938; Ward 1984).

Distribution and ecology.—**CANADA:** Alberta, British Columbia, Saskatchewan, Manitoba, Nova Scotia, Ontario and Québec. Darbyshire (2003) also mentioned it from NewFoundland, New Brunswick and Prince Edward Island. Although we found no herbarium collections, its presence in these provinces is possible. **U.S.A.:** Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Iowa?, Kansas, Kentucky, Louisiana, Massachusetts, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana?, Nebraska, Nevada, New Mexico, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, Wisconsin, Wyoming. *Cuscuta campestris* is the second most common species in North America, after *C. gronovii* (Yuncker 1932), and perhaps the most successful and widespread *Cuscuta* weed worldwide, recorded from South America, Europe, Asia, Africa, and Australia (Holm et al. 1997). Flowering Jun–Nov. **Hosts:** numerous species from hundreds of genera in various families, including Hydrophyllaceae, Chenopodiaceae,

Verbenaceae, Convolvulaceae, Acanthaceae, Brassicaceae, Euphorbiaceae, Solanaceae, Urticaceae, Polygonaceae, Fabaceae, Asteraceae, and others (Gaertner 1950), growing in a wide variety of climates and soil types; reported *not* to survive on *Amaranthus retroflexus*, *Arctium lappa*, *Atriplex* spp., *Brassica nigra*, *Equisetum arvense*, *Glycine max*, selected cultivars of *Lycopersicon esculentum*, *Portulaca oleracea*, *Tanacetum vulgare*, *Vicia villosa*, Cyperaceae and Poaceae (Gaertner 1950; Parker & Riches 1993; Dawson et al. 1994; Costea & Tardif 2006).

Conservation status.—G5 (common) (the same assessment in NatureServe 2005).

4. Cuscuta glabrior (Engelm.) Yuncker, Mem. Torrey Bot. Club 18:140. 1932. *Cuscuta pentagona* Engelm. var. *glabrior* (Engelm.) Gandhi, Thomas, & Hatch, Sida 12:372. 1987. *Cuscuta verrucosa* Engelm. var. *glabrior* Engelm., Amer. J. Sci. 43:341. 1842. LECTOTYPE (Yucker 1932): U.S.A. TEXAS. [Harris Co.?]: dry sterile prairies west of Houston, *Lindheimer s.n.* (MO). The protologue noted that var. *glabrior* [was growing] "with the preceding variety [i.e., *C. verrucosa* var. *hispidula*], *F. Lindheimer*: on Petalostemon, *Drummond* (3rd collection, No. 247)." Choice of the Drummond collection (III, 247) as lectotype of *Cuscuta verrucosa* Engelm. var. *glabrior* has been associated with Yuncker (1921), but there Yuncker instead chose the Drummond type for *C. pentagona* var. *verrucosa*, citing *C. verrucosa* var. *glabrior* as a synonym.

Cuscuta verrucosa Engelm., Amer. J. Sci. 43:341. 1842 (nom. invalid., non Sweet 1823). *Cuscuta arvensis* var. *verrucosa* Engelm., Trans. Acad. Sci. St. Louis 1:495. 1859. *Cuscuta pentagona* Engelm. var. *verrucosa* (Engelm.) Yuncker, Illinois Biol. Monogr. 6:142. 1921. LECTOTYPE (Yuncker 1921): U.S.A. TEXAS: no other locality, *Drummond III 247* (MO; ISOLECTOTYPE: TEX). Engelmann described *C. verrucosa* and two varieties of it: var. *hispidula* (treated by us as *C. indecora* var. *indecora*) and var. *glabrior*. He cited collections associated with both varieties but none for *C. verrucosa* in its typical form. In 1859, in valid use of the epithet as *C. arvensis* var. *verrucosa*, he cited "Texas, Drummond! III. 247; Lindheimer! 127" and others as syntypes. Yuncker (1921, p. 52), under the combination *C. pentagona var. verrucosa*, indicated that "*Drummond III 247*" at MO was the type (lectotype).

Cuscuta arvensis Beyr. ex Engelm. var. *pubescens* Engelm., Trans. Acad. Sci. St. Louis 1:495. 1859. *Cuscuta pentagona* Engelm. var. *pubescens* (Engelm.) Yuncker, Illinois Biol. Monogr. 6:142. 1921. *Cuscuta glabrior* var. *pubescens* (Engelm.) Yuncker, Mem. Torrey Bot. Club 18:141. 1932. LECTOTYPE (Yuncker 1921): "Texas (... Lindheimer in 1847)" (MO). Engelmann's protologue cited "Western Texas, Lindheimer! Wright! 135 (574)."

Stems 0.35–0.5 mm in diameter, creamy. **Inflorescences** loose to compact, glomerulate or corymbiform of 3–25(–30) subsessile to pedicellate flowers; pedicels 0.8–4(–5) mm; bracts like in *C. campestris*. **Flowers** 5-merous, 1.4–2.1(–2.5) mm (Fig. 2a), membranous, white or commonly reddish when fresh, yellow to reddish-brown when dried; papillae present on the perianth, ovaries/capsules and sometimes on the pedicels (Fig. 2b); laticifers obvious in the calyx and less evident in the corolla and ovary/capsule, isolated or arranged in rows, rotund, ovoid or elongated; calyx yellow to reddish-brown, shiny, ± reticulate, cupulate, about as long as corolla tube; divided 1/2–2/3, lobes not overlapping, ovate triangular, not carinate, margins entire, apex obtuse to subacute; **corolla** persistent; tube campanulate-globose, saccate between the lines of stamen attachments, (1.1–)1.5–2.1 mm long; lobes spreading to reflexed, lobes 1.2–1.75 mm

long, triangular to sublanceolate, margins entire, apex acute to acuminate, inflexed; **stamens** exserted, shorter than corolla lobes, anthers broadly elliptic to elliptic-oblong, 0.44–0.67 × 0.22–0.3 mm, filaments 0.4–0.7 mm; **pollen grains** 18–22.6 µm long; tectum imperforatum or with a few puncta; maximum diameter of puncta 0.2 µm; supratectal process granular to conical ± uniformly distributed; **infrastaminal scales** reaching the filament bases, ovate to spatulate, rounded, uniformly dense fimbriate; styles evenly filiform, 0.9–1.6 mm, as long as or longer than the ovary; stigmas capitate, globose. **Capsules** indehiscent to irregularly dehiscent, globose-depressed to depressed, 1.5–2.8 × 2.1–3.5 mm, not thickened or raised around the medium to large interstylar aperture, not translucent, persistent corolla enveloping 1/2–2/3 of the capsule. **Seeds** 4 per capsule, angled, subrotund to broadly elliptic, 0.95–1.15 × 0.85–1 mm, seed coat cells alveolate/papillate, 35–50 µm in diameter (Fig. 4c), epicuticular wax absent; hilum region subterminal, round, 0.13–0.2 mm in diameter, vascular scar 0.03–0.05 mm long, oblique. ***2n*** **=** ?

Distribution and ecology.—**U.S.A.:** Louisiana, New Mexico, Oklahoma, Texas, Utah; Mexico. Flowering Jun–Sep. **Hosts:** wide variety of herbaceous species, including *Amaranthus*, *Ambrosia*, *Amphiachyris*, *Asclepias*, *Convolvulus*, *Coreopsis*, *Croton*, *Dalea*, *Dyschoriste*, *Evolvulus*, *Gaura*, *Gilia*, *Hedeoma*, *Helenium*, *Lespedeza*, *Liatris*, *Machaeranthera*, *Medicago*, *Mimosa*, *Plantago*, *Prosopis*, *Tragia*, *Oenothera*, *Justicia*, *Polygonum*, *Ruellia*, *Solanum*, *Symphyotrichum*, *Thelesperma*, *Verbena*.

Conservation status.—G4G5 (the same assessment in NatureServe 2005).

According to Yuncker (1965, p. 6), *Cuscuta pentagona* var. *pubescens* (Engelm.) Yuncker "represents the extreme degree of papillation which covers the flower and extends down onto the pedicels. In var. *glabrior* the ovary and capsules are almost always more or less papillate while the corolla shows considerable variation in this character." We find continuous variation, and two varieties cannot be separated. Occasional plants that are hardly papillate can be distinguished from *C. campestris* by their calyx lobes, which are broadly triangular-lanceolate and not overlapping at the base and by the corolla enveloping the mature capsule (Fig. 2a).

5. Cuscuta runyonii Yuncker, Bull. Torrey Bot. Club 69:541. 1942. TYPE: U.S.A. TEXAS. Hidalgo Co.: La Joya, occasional, on dry hill tops, clay, 45 m, flowers cream white, hosts: *Coldenia canescens* and *Nama hispida*, 8 Jun 1941, *Runyon 2732* (HOLOTYPE: US; ISOTYPES: F, GH, MO, NY, TEX).

Stems 0.35–0.5 mm in diameter, yellow-orange. **Inflorescences** loose, ± umbellate of 2–15(–25) subsessile to pedicellate flowers; pedicels 0.8–4(–5) mm; bracts as in *C. campestris*. **Flowers** 5-merous, 2.5–3.5(–4) mm (Fig. 2c), white to creamy when fresh, reddish-brown when dried, membranous, **papillae** present on the perianth, ovary/capsules and sometimes on the pedicels; **laticifers** evident in

the perianth and less obvious in the ovary/capsule, isolated or arranged in rows, rotund, ovoid or tangentially elongated; **calyx** reddish-brown, ± reticulate, shiny, cupulate, shorter than corolla tube or about equaling it, divided 1/2–2/3 the length, lobes not basally overlapping, triangular, sometimes carinate, base of calyx corresponding to each lobe with a reflexed spur-like projection, 0.1–0.6 mm long (Fig. 2c), and often with smaller protuberances on the midveins of calyx lobes, margins entire, apex obtuse to subacute; **corolla** persistent; tube campanulate-globose, saccate between the lines of stamen attachments, (1.2–)1.6–2.3 mm, lobes reflexed, 1.2–2 mm, triangular-ovate to lanceolate, margins entire, apex acute to acuminate, inflexed; **stamens** exerted, shorter than corolla lobes anthers broadly elliptic to elliptic-oblong, 0.4–0.6 × 0.25–0.3 mm, filaments 0.4–0.6 mm long; **pollen grains** 18–23.8 µm long; tectum imperforatum or with a few puncta; maximum diameter of puncta = 0.3 µm; supratectal process granular to conical ± uniformly distributed; infrastaminal scales reaching the filament bases, oblong to spatulate, rounded, uniformly dense fimbriate; styles evenly filiform, 0.9–1.8 mm, equaling to longer than the ovary; stigmas capitate, globose. **Capsules** indehiscent to irregularly dehiscent, globose-depressed, 1.6–3 × 2–3.4 mm; not thickened or raised around the large interstylar aperture large, not translucent, persistent corolla enveloping 1/2–1/1 of the capsule. **Seeds** 4 per capsule, angled, ovate to broadly elliptic, 0.95–1.40 × 0.85–1.1 mm, seed coat cells alveolate/papillate, 30–50 µm in diameter; epicuticular wax present with longitudinal; rodlets hilum region subterminal round to subrotund, 0.30–0.40 mm, vascular scar, 0.08–0.09 mm long, oblique (Fig. 4d). ***2n*** **=** ?

Distribution and ecology.—**U.S.A.:** Texas. Flowering Mar–Apr(–May, –July, –Oct). **Hosts:** species of *Dalea, Dyschoriste, Erigeron, Gutierrezia, Hymenoxys, Justicia, Linum, Melampodium, Oenothera, Nama, Spermolepis, Tetraneuris, Tiquilia, Thamnosma, Thelesperma.*

Conservation status.—G3 (vulnerable) (G4, NatureServe 2005).

6. Cuscuta plattensis A. Nels., Bull. Torrey Bot. Club 26:131. 1899. TYPE: U.S.A. WYOMING. [Carbon Co.?]: Platte Canyon, 27 Aug 1896, *A. Nelson 2768* (HOLOTYPE: RM; ISOTYPES: NY, US).

Stems 0.15–0.3 mm in diameter, yellow to pale orange. **Inflorescences** loose, paniculiform of 2–10(–15) subsessile to pedicellate flowers; pedicels 0.5–2.5(–3) mm.; bracts as in *C. campestris*. **Flowers** 5-merous, 3–4.6(–5) mm (Fig. 2d), membranous, white-creamy when fresh, whitish-yellow when dried; **papillae** absent; **laticifers** present in the calyx and less obvious in the corolla and capsule, isolated, ovoid to elongated; **calyx** yellow, reticulate, not shiny, cylindric-cupulate, ca. equaling the corolla tube, divided 1/2–2/3, lobes slightly basally overlapping, ovate triangular, not carinate, margins entire, obtuse to subacute; **corolla** persistent; tube narrowly campanulate to cylindric campanulate, not saccate, 1.9–2.5 mm, lobes spreading to reflexed, 1.4–2.2 mm long, triangular,

margins entire, apex narrowly acute, inflexed; **stamens** exserted, shorter than corolla lobes anthers subrotund, broadly elliptic to elliptic-oblong 0.4–0.7 × 0.3–0.4 mm, filaments 0.3–0.4 mm; **pollen grains** 18–26.3 µm long; tectum imperforatum or with a few puncta; diameter of puncta 0.2 µm; supratectal process granular ± uniformly distributed (Fig. 3c); **infrastaminal scales** 3/4–4/5 of the corolla tube, oblong-spathulate, rounded uniformly dense fringed to fimbriate; styles uniformly filiform, 1.3–1.6 mm, about as long as the ovary; stigmas capitate, globose. **Capsules** indehiscent to irregularly dehiscent, globose to globose-depressed, 1.8–3.2 × 2.2–3.6 mm, not thickened or raised around the large intersylar aperture; not translucent, withered corolla persistent enveloping 1/2 or more of the capsule base. **Seeds** 1–4 per capsule, dorsoventrally compressed, broadly elliptic to obovate, 1.07–1.42 × 0.9–1.21 mm, seed coat cells alveolate/papillate, 15–20 µm in diameter; epicuticular wax absent; hilum region subterminal, subrotund, 0.30–0.35 × 0.28–0.30 mm, vascular scar 0.20–0.25 mm long, vertical to slightly oblique (Fig. 4f). ***2n*** **=** ?

Distribution and ecology.—**U.S.A.:** Nebraska, Washington, and Wyoming. Flowering Aug. **Hosts:** species of *Grindelia, Helianthus, Humulus Psoralea, Rubus, Solidago.*

Conservation status.—G1 (critically imperiled) (the same assessment in NatureServe 2005).

7. Cuscuta sandwichiana Choisy, Mem. Soc. Phys. Hist. Nat. Geneve 9:280. 1841.
TYPE: U.S.A. HAWAII. Sandwich Islands, 1830, *Gaudichaud-Beaupré 1* (HOLOTYPE: G-DC, fragment NY; ISOTYPE: P, fragment NY).

Stems, 0.2–0.5 mm, yellow-orange. **Inflorescence** loose, paniculiform of 3–7(–11) pedicellate flowers; pedicels 2–5 mm; bracts 1 at the base of clusters, usually lacking at the base of pedicels, membranous, narrow-triangular, 1–1.6 × 0.7–1 mm, margins entire, apex acute. **Flowers** (4–)5-merous, 3–4(–5) mm long (Fig. 5a), fleshy, white when fresh, yellow-brownish when dried; **papillae** absent; **laticifers** conspicuous in the corolla lobes, sometimes in the calyx and ovary/capsule as well, isolated or in rows, ovoid to elongated; **calyx** yellow-brown, not reticulate or shiny, cupulate, almost as long as corolla tube, divided 1/2–1/3 the length, lobes not basally overlapping, triangular-ovate, in some flowers carinate, margins entire, apex obtuse to subacute; **corolla** persistent; tube campanulate to globular, not saccate, 2–3 mm long, lobes erect to slightly spreading, 0.8–1.5 mm long, ovate-triangular, margins entire, apex obtuse to subacute with inflexed tips; **stamens** mostly included, shorter than corolla lobes, anthers broadly-elliptic 0.5–0.7 × 0.4–0.5 mm, filaments 0.2–0.7 mm; **pollen grains** 22–27.5 µm long; tectum imperforatum or with a few puncta; maximum diameter of puncta 0.3 µm; supratectal process granular to conical, ± uniformly distributed; **infrastaminal** scales absent or reduced, bifid, truncated or triangular, distally with a few teeth; styles uniformly stoutish, 0.5–1.1 mm, ca. as long as the

ovary; stigmas capitate, globose. **Capsules** indehiscent to irregularly dehiscent, globose to globose-depressed, 2.5–3.5 mm × 3.3–4 mm, ± thickened but not raised around the large interstylar aperture, not translucent, withered corolla surrounding the capsule. **Seeds** usually 2 per capsule, angled, elliptic to broadly-elliptic, 1.1–2 × 1–1.7 mm, seed coat cells alveolate/papillate, 35–50 µm in diameter, epicuticular wax absent; hilum region subterminal, round, 0.30–0.45 mm in diameter, vascular scar 0.19–0.25 mm long, vertical or slightly oblique (Fig. 5b). ***2n*** = ?

Distribution and ecology.—**U.S.A.:** Hawaii. Flowering summer–fall (Jun–Oct). **Hosts:** plants in seashores and arid habitats.

Conservation status.—G2 (imperiled) (the same assessment in NatureServe 2005).

8. Cuscuta obtusiflora Kunth var. **glandulosa** Engelm., Trans. Acad. Sci. St. Louis 1:492. 1859. *Cuscuta glandulosa* (Engelm.) Small, Fl. S.E. U.S. 969, 1337. 1903. LECTOTYPE (Yuncker 1921): U.S.A. GEORGIA. [Muscogee Co.]: Columbus, 1838, *Boykin s.n.* (MO). The protologue cited numerous collections in addition to the Boykin one.

Stems 0.25–0.4 mm in diameter, orange. **Inflorescences** dense, glomerulate of 5–18 sessile or subsessile flowers; pedicels absent to 1 mm; bracts 1 at the base of clusters and 0–1 at the base of pedicels/flowers, membranous, ovate, 0.5–1.3 × 0.2–1.1 mm, margins entire, apex acute to obtuse. **Flowers** 5-merous, 1.8–2.5 mm, membranous, creamy white when fresh, yellow-brown when dried; **papillae** absent; **laticifers** numerous, evident in the perianth and ovary/capsule, isolated, round to ovoid; **calyx** yellow-brownish not reticulate or shiny, shallowly cupulate, about equaling the corolla tube, divided ca. 1/2 the length, lobes barely basally overlapping, ovate, not carinate, margins entire, apex obtuse; **corolla** persistent; tube campanulate, not saccate, 1–1.5 mm, lobes erect to spreading, 0.8–1.5 mm long, ovate to ovate-oblong, margins entire, apex obtuse, straight; **stamens** exserted, shorter than corolla lobes, anthers ovate to broadly elliptic, 0.3–0.4 × 0.2–0.3 mm, filaments 0.4–0.6 mm; **pollen grains** (18–)20–24(–27) µm, tectum perforatum; maximum diameter of puncta 0.6 µm; supratectal process granular to conical ± uniformly distributed (Fig. 5c); infrastaminal scales reaching the filament bases, oblong, rounded, with a few basal fimbriae, densely fringed in the distal 3/4; styles uniformly stoutish, 0.4–1.1 mm, shorter than or equaling the ovary, stigmas capitate, globose. **Capsules** indehiscent to irregularly dehiscent, depressed-globose, 1.5–3 × 2.5–4 mm, not thickened or raised around the large interstylar aperture, not translucent, withered corolla persistent at the base. **Seeds** usually 4 per capsule, dorsoventrally compressed, broadly-ovate to broadly elliptic, 1.4–1.56 × 1.23–1.35 mm, seed coat cells alveolate/papillate, 20–30 µm in diameter, epicuticular wax usually present (Fig. 5d). ***2n*** = ?

Distribution and ecology.—**U.S.A.:** Alabama, Arkansas, Connecticut, Florida, Georgia, Kentucky, Louisiana, Minnesota, Mississippi, New York., Oklahoma.,

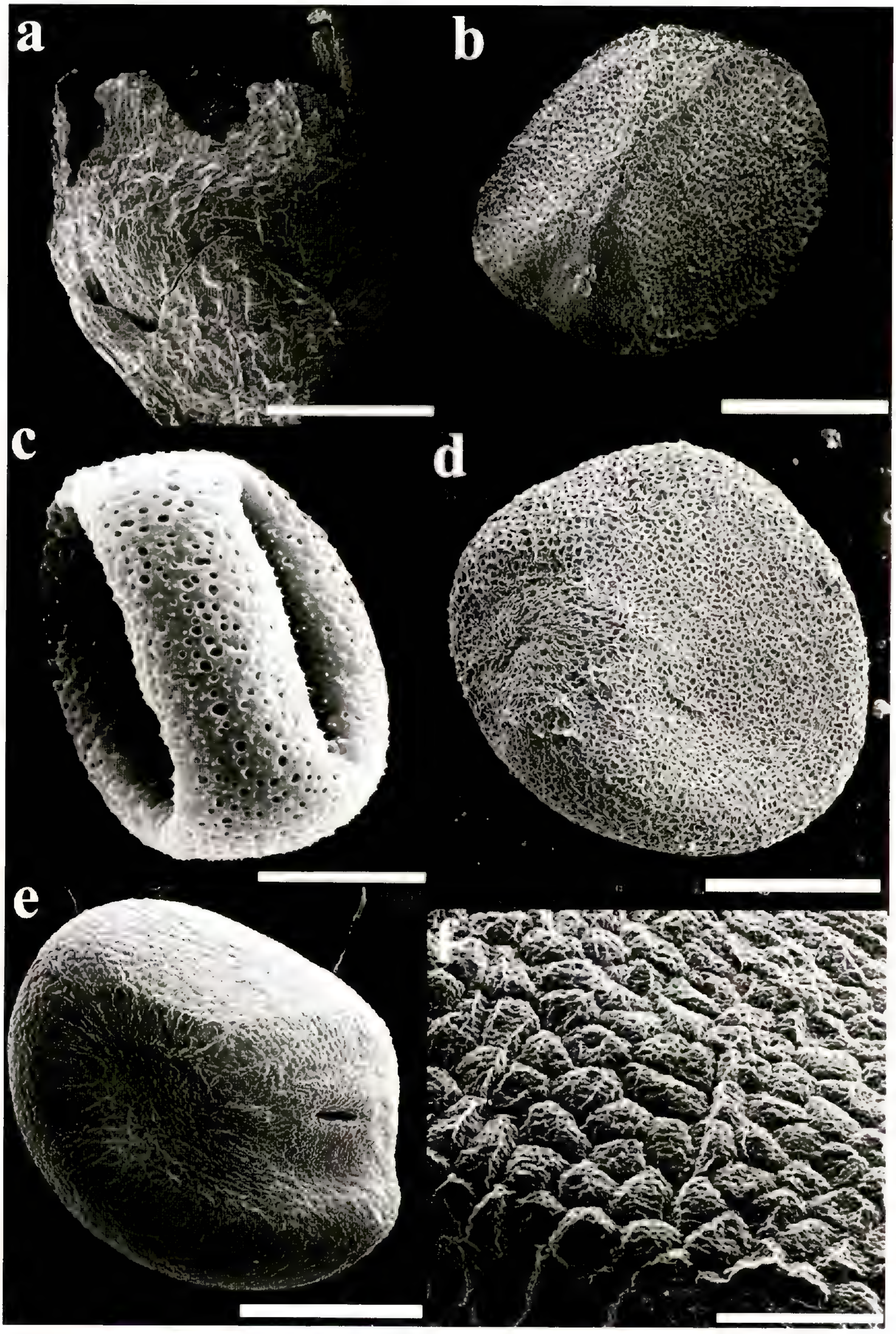


FIG. 5. *Cuscuta sandwichiana*. **a.** Flower (scale bar = 1 mm); **b.** seed (scale bar = 0.6 mm). *Cuscuta obtusiflora* var. *glandulosa*. **c.** Pollen (scale bar = 6 μm); **d.** seed (scale bar = 0.5 mm). *Cuscuta polygonorum*. **e.** Seed—general morphology (scale bar = 0.60 mm); **f.** seed—surface micromorphology (scale bar = 100 μm).

Pennsylvania, Texas; Mexico, West Indies (Puerto Rico, Cuba). Flowering Jul–Sep, –Oct. **Hosts:** species of *Alternanthera*, *Dalea*, *Hygrophila*, *Lythrum*, *Polygonum*, *Xanthium*.

Conservation status.—G3G4 (vulnerable to apparently secure) (G4, NatureServe 2005).

9. Cuscuta polygonorum Engelm., Amer. J. Sci. Arts 43:342. 1842. TYPE: U.S.A. MISSOURI: W of St. Louis, ["bottoms of sink-holes, or margins of ponds"], on *Polygonum*, Aug 1839, *Lindheimer s.n.* (HOLOTYPE: MO).

Stems 0.2–0.4 mm in diameter, yellow-orange. **Inflorescences** dense, glomerulate of 4–18 sessile to subsessile flowers; bracts 1 at the base of clusters and 0–1 at the base of pedicels, membranous, ovate-triangular to lanceolate, 0.3–1 × 0.2–0.9 mm, margins entire, apex acute; pedicels absent to 1 mm. **Flowers** (3–)4-merous, 2–2.7 mm, membranous, white when fresh, yellow-brown when dried; **papillae** absent; **laticifers** evident in the corolla and the ovary/capsule, isolated, round to ovoid; **calyx** yellow-brownish, not shiny or reticulate, cupulate, ca. equaling the corolla tube, divided 1/2–2/3 to the base, lobes not basally overlapping, triangular-ovate, not carinate, margins entire, apex obtuse to rounded; **corolla** persistent, tube cupulate to shallowly campanulate, not saccate, 1–1.4 mm, lobes erect, 1.1–1.6 mm long, triangular, margins entire, apex acute, straight; **stamens** exserted, shorter to nearly equaling corolla lobes, anthers ovate to broadly elliptic, 0.3–0.4 × 0.2–0.3 mm, filaments 0.4–0.7 mm; **pollen** grains (18–) 21–24.5 (–26) µm long, tectum imperforatum or with a few puncta; maximum diameter of puncta 0.3 µm; supratectal process granular to conical ± uniformly distributed; **infrastaminal scales** usually reaching the filament bases, oblong, mostly shallowly bifid with 1–3 fimbriae on each side of the filament attachment or with a few irregular fimbriae at the apex; styles evenly subulate, 0.4–0.9 mm, shorter than the ovary; stigmas capitate, globose. **Capsules** indehiscent to irregularly dehiscent, depressed-globose, often appearing angled, 1.6–3 × 2.5–5 mm, not thickened or raised around the large interstylar aperture, not translucent, withered corolla persistent the capsule base. **Seeds** usually 4 per capsule, dorsoventrally compressed, subrotund, broadly ovate to broadly elliptic, 1.45–1.6 × 1.25–1.39 mm, seed coat cells alveolate/papillate or poliedric, 20–30 µm in diameter, epicuticular wax usually present; hilum region subterminal scar area slightly raised, elliptic, 0.45–0.6 × 0.3–0.35 mm; vascular scar 0.15–0.2 mm, vertical or slightly oblique (Fig. 5 e,f). ***2n*** **=** ?

Distribution and ecology.—**CANADA:** Ontario, Québec. **U.S.A.:** Arkansas, Connecticut, District of Columbia, Delaware, Iowa, Illinois, Indiana, Kansas, Kentucky, Louisiana, Massachusetts, Maryland, Maine, Michigan, Minnesota, Missouri, North Dakota, Nebraska, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, Rhode Island, Tennessee, Texas, Virginia, Wisconsin. Flowering

Jul–Oct. **Hosts:** usually *Polygonum* but occasionally also on *Impatiens*, *Ipomoea*, *Lycopus*, *Penthorum*, *Xanthium*, and others.

Conservation status.—G3 (vulnerable) (G5, NatureServe 2005).

APPENDIX 1.
VOUCHERS FOR THE SEM STUDY

Vouchers are from NY unless otherwise indicated.

1. **Cuscuta pentagona** (16 collections examined).—**U.S.A. DISTRICT OF COLUMBIA.** Eastern Branch near Mt. Hamilton, 2 Aug 1919, *Killip 6338*. **FLORIDA. Lake Co.:** 3 mi S of Sorrento, *Welch 1633*. **GEORGIA. Whitfield Co.:** field E of Dicks Ridge, 1000 ft, 27 Jul 1900, *Wilson s.n.* **INDIANA. Lawrence Co.:** 2 mi W of Bedford, flood plain of Salt Creek, 23 Aug 1934, *Kriebel 2518*. **KANSAS. Trego Co.:** 19 mi S and 2 mi W of Collier, 6 Aug 1952, *David & Harr 4136*. **MASSACHUSETTS. Middlesex Co.:** Winchester, Winter Pond, 22 Sep 1908, *Fernald & Weatherby s.n.* **MICHIGAN. Kalamazoo Co.:** Fort Custer, 12 Aug 1945, *Hanes 4541*. **MISSOURI. Phelps Co.:** Jerome, 27 Jul 1931, *Kellog s.n.* **NEW JERSEY. Ocean Co.:** Bay Head, 31 Jul 1910, *Mackenzie 4742*. **NEW YORK.** (no county given). Long Island, 8 Aug 1903, *Bicknell s.n.* **NORTH CAROLINA. Franklin Co.:** Franklin, 23 Jul 1888, *Johnson s.n.* **NORTH DAKOTA. Barnes Co.:** Eckelson, 15 Sep 1937, *Stevens s.n.* **Benson Co.:** Cranberry Lake, 8 Sep 1930, *Stevens s.n.* **TENNESSEE. Wayne Co.:** 4 mi W of Waynesboro, 10 Aug 1934, *Welch 1382*. **VIRGINIA. Arlington Co.:** 1/4 mi SE Hatfield, 9 Jul 1939, *Hermann 10391*; W of Williamsburg, 15 Aug 1921, *Weatherby 4230*.

2. Cuscuta campestris (23 collections examined).—**CANADA. QUÉBEC.** Montreal, Aug 1940, *Cartier s.n.* **ONTARIO. Waterloo Co.:** Galt, 26 Sep 1908, *Herriot s.n.* **Wellington Co.:** Guelpn, 3 Aug 1943, *Howitt s.n.* **U.S.A. ARKANSAS. Craighead Co.:** Jonesboro, 260 ft, 6 Jun 1948, *Demaree 26643*. **Garland Co.:** Hot Springs, 500 ft, 17 Jul 1938, *Demaree 17932*. **CALIFORNIA. Los Angeles Co.:** Los Angeles, 10 Jul 1933, *Demaree 10533*. **IDAHO. Ada Co.:** Harrison Hollow on NE side of Boise, T4N R2E Sec 34 SENW, 2710 ft, 13 Aug 1980, *Ertter & Strachon 3951*. **FLORIDA. Dade Co.:** at 14000 SW 8th Road, Miami, 12 Nov 1974, *Corell 43759* (NY). **GEORGIA. Clarke Co.:** Athens, at 285 Hillcrest, 800 ft, 11 Nov 1946, *Cronquist 4209*. **INDIANA. Harrison Co.:** 4 mi SE of Central, 26 Aug 1945 *Deam s.n.*. **Wells Co.:** 5 mi NE of Bluffton, 26 Aug 1940, *Deam 59866*. **KENTUCKY. Fayette Co.:** Gentry Thompson stockyards, Lexington, 2 Sep 1944, *McFarland s.n.* **MARYLAND. Wicomico Co.:** Willards, 4 Sep 1942, *Moldenke 13847*. **NEVADA. Douglas Co.:** Carson River, ca. 7 mi N of Minden, 4700 ft, 14 Sep 1969, *Howell 46198*. **NEW MEXICO. Grant Co.:** 1880–1881, *Rusby 295*. **NEW YORK. Onondaga Co.:** Syracuse, shore of Onondaga Lake, *Gaertner s.n.* **OREGON. Marion Co.:** Salem, Willamette River, 13 Jul 1922, *Nelson 4407*. **TENNESSEE. Knox Co.:** N of Knoxville, Wallace's Orchard, 6 Aug 1943, *Wilson 3007*. **TEXAS. Childress Co.:** 3.4 mi E of Childress, S of Hwy. 287, 6 Sep 1945, *Whitehouse 10715*. **Tom Green Co.:** South Caucho River, 8 mi N by E of Christoval, 29 Aug 1943, *Cory s.n.* **UTAH. Sanpete Co.:** T14S, R2E, SEC 22, 4 mi NE of Fountain Green on U-132, 9000 ft, 19 Jul 1977, *Neese & White 3682*. **VIRGINIA. Nansemond Co.:** Suffolk, 24 Jul 1893, *Heller s.n.*

3. Cuscuta glabrior (15 collections examined).—**U.S.A. OKLAHOMA. Murray Co.:** Sulphur, Platt National Park, 28 May 1935, *Merril 522*. **Pontotoc Co.:** 2 mi SW of Ada, near State Hwy. 12, 26 Jun 1947, *Robbins 2607*. **NEW MEXICO.** (no locality given) 1851–1852, *Wright 1635*. **TEXAS. Bell Co.:** Near Little River, 11 June 1930, *Wolff 2274*; Killen, 14 Aug 1931, *Wolff 3270*. **Bexar Co.:** 16 mi E of San Antonio, 27 Apr 1921, *Schulz 453*; San Antonio, 17 Apr 1911, *Clemens s.n.* **Burnet Co.:** along State Hwy. 29, 7 mi E of Burnet, *Webster & Rogers 6476*. **Coleman Co.:** 7 mi E of Santa Anna, 29 Jun 1958, *Correll & Johnston 19019*. **Dallas Co.:** Dallas, 30 Jun 1872, *Hall s.n.* **Edwards Co.:** 29 mi NW of Rocksprings, 27 Jun 1943, *Cory s.n.* **Ellie Co.:** above Red Oak Creek off Waco road, 10 Jun 1940, *Lundell & Lundell 9353*. **Neueces Co.:** Corpus Christi, 0–40 ft, 9–12 Apr 1894, *Heller s.n.* **Randall Co.:** Buffalo Lake National

Wildlife Refuge, 3 Aug 1975, *Higgins 9567*. **Terrell Co.:** low hills in upper big Canyon, ca. 30 mi N of Sanderson toward Sheffield, 2800 ft, *Warnock 14730*.

4. Cuscuta runyonii (5 collections examined).—**U.S.A. TEXAS. Duval Co.:** of Hyw. 44 NE of San Diego, 20 Apr 1949, *Lundell 14906*. **Hidalgo Co.:** 2 mi N of La Joy, 45 m, 13 Jul 1941, *Runyon 2825*. **Starr Co.:** Brownsville, 50 m, 27 Apr 1941, *Runyon 2622*. **Webb Co.:** ca. 21 mi from junction of Hwys. 81 & 83, along Hwy. 83, 1 Apr 1949, *Tharp & York 52-163*; 46 mi NE of Laredo, route #59, 17 Jul 1958, *Correll & Johnston 14906*.

5. Cuscuta harperi (5 collections examined).—**U.S.A. ALABAMA. Cherokee Co.:** Lookout Mt. at the edge of gorge of May's Gulf, *Harper s.n.* **De Kalb Co.:** Desoto State Park, above Fort Payne, in Little River Canyon, 8 Oct 1960, *Sherman et al. 27757;* Glades, 1200 ft, 13 Oct 1962, *Demaree 46295*; Lookout Mt., Jul 1898, *Ruth 473*. **Etowah Co.:** Black Creek just above Noccalula Falls, Lookout Mt., 31 Aug 1911, *Harper 147*.

6. Cuscuta plattensis (2 collections examined).—**U.S.A. WYOMING. Goshen Co.:** 3 mi NE of Torrington, T25N R60W Sec 31 S1/2 SW 1/4, 4200 ft, 15 Aug 1993, *Dorn 5470*. **Niobrara Co.:** near Newcastle, 24 Jul 1942, *Degener & Peiler 16242*.

7. Cuscuta sandwichiana (3 collections examined).—**U.S.A. HAWAII. Hawaii Co.:** East Maui, Makawao, Kaunauhae, La Perouse Bay, 30 Apr 1978, *Sylva & Rumel s.n.;* O'ahu, Ka'ena Pt., 29 Nov 1969, *Char 40*; O'ahu, Makapu'u Beach Park, 4 Oct 1960, *Fujiwara s.n.*

8. Cuscuta obtusiflora var. glandulosa (5 collections examined).—**U.S.A. ARKANSAS. Ashley Co.:** Lone Prairie, Prairies, 15 Sep 1940. *Demaree 21543*. **INDIANA. White Co.:** in the Tippecanoe River, ca. 1 mi below Monticello, 14 Aug 1925, *Deam 41990*. **OKLAHOMA. Haskell Co.:** stream ca. 5 mi S of the intersection of Hwy 2 with Hwy 31, 22 Jul 1967, *Mitchell 3387*. **TEXAS. Dallas Co.:** Bachmans Dam, bordering lake, wet area, 1 Sep 1942, *Lundell & Lundell 11717*; 24 Aug 1942, *Lundell 11626*.

9. Cuscuta polygonorum (7 collections examined).—**U.S.A. ARKANSAS. St. Francise Co.:** 5 mi S of Forrest City, 19 Sep 1959, *McDaniel 1419*. **INDIANA. Putnam Co.:** 2 mi E of Bainbridge, 20 Oct 1941, *Yuncker 10836*. **NEBRASKA. Otoe Co.:** extreme S part of SE1/4, NE1/4, Sec 25, T8N-R14E, 11 Sep 1974, *Sutherland 4096*. **NEW JERSEY, Somerset Co.:** Millstone, plaine de débordement de la rivière Millstone, 4 Aug 1956, *Lavoie 452* (QUE). **NEW YORK.** [county not indicated; **Nassau Co.?**] Long Island, Plattsdale, 19 Sep 1925, *Ferguson 4608*. **OHIO. Ottawa Co.:** Duck Club, Winous Pt., 4 Aug 1949, *Core & Anderson s.n.* **WISCONSIN. Winnebago Co.:** swampy area along the shore of lake Winnebago, N beyond the end of Hazel St., N of Murdock, in Oshkosh, 25 Jul 1965, *Arriman 598* (UNB).

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Book Review

Dietrich Frohne and Hans J. Pfander. Patrick McKinney, Kirk Cumpston (Consult. Eds.). (Translated by Inge Alford). 2005. **Poisonous Plants: A Handbook for Doctors, Pharmacists, Biologists and Veterinarians, Second Edition.** (ISBN 008192-750-3, hbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax.). $150.00, 480 pp., 224 color photos, 131 b/w illustrations, 20 tables, 115 diagrams, 9 1/2" × 10 1/2".

Many seemingly innocuous plants harbor toxins that can cause serious illness and even death. This authoritative text is intended for pharmacists, poison control center personnel, doctors, veterinarians, and other professionals who deal with poisoning cases, although it is useful to those interested in wild foods and wildcrafting medicinal herbs. It opens with a concise introduction to poisonous plants, including how poisoning can occur, what to do in suspected cases of poisoning, and descriptions of toxic phytochemicals. The rest of the book contains clear descriptions of poisonous plants, arranged by family from Aceraceae to Zygophyllaceae. The text is complete with descriptions of macroscopic and microscopic plant morphology, symptoms, treatments, and references. Excellent color photographs illustrate each section. The first English edition of this book was published 20 years ago. This second English edition contains updated information, including an expanded appendix with notes on poisonous plants found in North America. Not intended to be a field guide, this book is still an excellent reference book.—*Marissa Oppel, MS, Herbarium Technician, Botanical Research Institute of Texas, Fort Worth, Texas 76102-4060, U.S.A.*

Book Notice

Carmen Ulloa Ulloa and D.A. Neill. 2005. **Cinco años de adiciones a la flora del Ecuador: 1999-2004.** (ISBN 9978-09-578-0, pbk.). Universidad Técnica Particula de Loja, Missouri Botanical Garden, Funbotanica. Editorial, UTPL, Loja. (**Orders:** Available at Missouri Botanical Garden Press, http://www.mbgpress.info/). $16.00, [Reduced price available only at UTPL, Loja]. 75 pp., 8 1/2" × 11".

Summary.—Of the 1246 new additions to the Ecuadorian flora, 820 are new taxa described from Ecuadorian material, 337 names are new records for Ecuador, and 89 are taxonomic changes. The new total for the flora is of 17,058 species of vascular plants. Some 242 new bibliographic references are listed.

TAXONOMY OF THE *CUSCUTA SALINA-CALIFORNICA* COMPLEX (CONVOLVULACEAE)

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ABSTRACT

The *Cuscuta californica* complex (*Cuscuta* subsect. *Californicae*) is recircumscribed to include the species from subsect. *Subinclusae*. The species include *C. salina*, *C. susksdorfii*, *C. californica*, *C. occidentalis*, *C. subinclusa*, and *C. howelliana*. A summary of relevant taxonomic information is provided, along with a key to species and varieties, synonymy, distribution, host range, and conservation status. Morphology and micromorphology of flowers, seeds, and capsules are analyzed and illustrated.

RESUMEN

El complejo *Cuscuta californica* (*Cuscuta* subsect. Californicae) está circunscrito a incluir las especies de subsect. *Subinclusae*. Las especies incluyen *C. salina*, *C. susksdorfii*, *C. californica*, *C. occidentalis*, *C. subinclusa*, y *C. howelliana*. En este trabajo se presenta un resumen de la información taxonómica junto con una clave para identificar las especies y variedades, sinónimos, distribución, variabilidad de huéspedes y estato de conservación. Se analizan e ilustran la morfología y micromorfología de las flores, de las semillas y de las cápsulas.

Yuncker (1932) described and defined *Cuscuta* subsect. *Californicae* and subsect. *Subinclusae* mainly on the basis of absence or presence, respectively, of infrastaminal scales. He suggested that both sections were derived independently but in parallel from subsect. *Arvenses*. In Yuncker's view, subsect. *Californicae* comprised five species: *C. californica* Hook. & Arn., *C. occidentalis* Millsp., *C. brachycalyx* Yuncker, *C. jepsonii* Yuncker, and *C. sandwichiana* Choisy, while subsect. *Subinclusae* included three species: *C. salina* Engelm., *C. suksdorfii* Yuncker, and *C. subinclusa* Durand & Hilgard (Yuncker 1932, 1965). *Cuscuta howelliana* Rubtzoff was recently described (Rubtzoff 1966) and noted by its author to have similarities to *C. suksdorfii* of subsect. *Subinclusae*.

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Definitions and interrelationships among these taxa are complex. Beliz (1993) included *Cuscuta brachycalyx*, *C. occidentalis*, and *C. suksdorfii* as synonyms of *C. californica* var. *breviflora* Engelm. *Cuscuta subinclusa* and *C. howelliana* were hypothesized to be sister species in a separate clade (Beliz 1986). Some taxa were described in one subsection and later were reclassified in the other. For example, Engelmann (1859) initially described *C. salina* as "?*C. californica* var. *squamigera*" and as *C. subinclusa* var. *abbreviata* (see also the example below of *C. suksdorfii*). *Cuscuta sandwichiana* (Beliz 1986; Costea et al. 2006a) and *C. jepsonii* (Beliz 1986; Costea et al. 2006c) do not appear to be evolutionarily related to this group.

Circumscriptions of these taxa and an assessment of their relationships are provided here on the basis of the morphology and micromorphology of flowers, capsules, seeds, and pollen. Conservation status is assessed for all taxa.

METHODS

Descriptions of morphology (see Costea et al. 2006a) are based on samples from specimens of the NY, JEPS, and UC herbaria (Appendix 1). Measurements and pictures were taken with a scanning electron microscope Hitachi S-570 at 15 KV. Samples were coated with 30 nm gold using an Emitech K 550 sputter coater. Conservation status was determined using NatureServe (2005) ranks and criteria.

TAXONOMY

Delimitation of the *Cuscuta salina-californica* complex

Our observations suggest that the species of subsections *Californicae* and *Subinclusae* form a single phylogenetic group. We hypothesize that infrastaminal scales have undergone a gradual reduction from fimbriate scales or ridges in *C. salina*, to dentate wings in *C. suksdorfii*, to complete reduction in *C. californica* and *C. occidentalis*. A similar reduction of infrastaminal scales has occurred in *C. indecora* complex (subsect. *Indecorae* Yuncker) (Costea et al. 2006c). *Cuscuta subinclusa* and *C. howelliana* have well-developed infrastaminal scales and were suggested by Beliz (1986) to form a distinct clade in which a cylindric-campanulate corolla has evolved as a specialization to butterfly pollination. Although *C. subinclusa* and *C. howelliana* are distinct in their microreticulate pollen (see descriptions below), close similarities in morphology and micromorphology of calyx, corolla lobes, seeds, and capsules (see below) indicate that they probably belong to the same phylogenetic group as *C. californica*, *C. salina*, and *C. suksdorfii*. A cylindric-campanulate corolla sometimes occurs in *C. californica*, and Engelmann (1876) noted that "in many respects [*C. salina*] is intermediate between the preceding [*C. californica*] and the following species [*C. subinclusa*]." Yuncker (1932, 1965) observed that the corolla of *C. subinclusa* is "usually showing horizontal ridges between the stamen at-

tachments" and we find this characteristic in some flowers of *C. californica* as well. The original description of *C. howelliana* (Rubtzoff 1966) noted that it is similar to *C. suksdorfii* var. *subpedicellata*.

Cuscuta jepsonii and *C. sandwichiana* were included by Yuncker (1932) in subsect. *Californicae* (the latter species omitted in the treatment from 1965) because they exhibit a similar reduction of the infrastaminal scales. *Cuscuta jepsonii*, however, may be evolutionarily related to taxa of *Cuscuta indecora* complex (Costea et al. 2006c). *Cuscuta sandwichiana* is a Hawaiian endemic and was hypothesized by Costea et al. (2006a) to belong to the *C. pentagona* complex.

In conclusion, the *Cuscuta salina-californica* complex in our view includes *C. salina*, *C. susksdorfii*, *C. californica*, *C. occidentalis*, *C. subinclusa*, and *C. howelliana*, which are recognized here as *Cuscuta* subsect. *Californicae* Yuncker (including subsect. *Subinclusae*). Taxonomically and nomenclaturally problematic species are discussed below.

Cuscuta subinclusa.—Curran (1885) noted that "from the description, [*C. ceanothi* is] evidently *C. subinclusa*," and the former name has been used by most authors (e.g. Yuncker 1965) because it has priority. From Curran's observation it can be inferred that the type collection of *C. ceanothi* was not available even at 1885. This collection may have been destroyed during the fire following the San Francisco earthquake from 1906 or even at an earlier date. As observed by Beliz (1986), it is possible that the name *C. ceanothi* refers to a species distinct from *C. subinclusa*. The protologue of *C. ceanothi* states that flowers are urceolate with obtuse calyx lobes, features not encountered in *C. subinclusa* or in any species hypothesized to be closely related. In a letter addressed to Engelmann on 10 Nov 1860 (Ertter 2003), Behr wrote: "Of *Cuscuta* I know two kinds, the one quite common on *Salicornia* (*C. salina*?), the other climbs on *Ceanothus*. Of the latter I gave once a diagnosis in the transactions (Proc. Calif.) under the preliminary name *Cuscuta ceanothi*. This diagnosis is by the nature of a search very incomplete, as for comparison I had only the just-mentioned parasitic kind on the *Salicornia* and none of the more closely related exotics." In a summary of the San Francisco flora (1888), approximately three decades after describing *C. ceanothi*, Behr mentioned *C. subinclusa* but not *C. ceanothi*. Without neotypification, there apparently is no way to establish the identity of *C. ceanothi*, and until more certainty might exist that *C. ceanothi* is not a distinct and evidently rare species, we use the later name *C. subinclusa* for the known species.

Cuscuta suksdorfii.—Yuncker (1921) described *C. salina* var. *acuminata* Yuncker, which he later (1932) treated at specific rank as *C. suksdorfii*. This species is "closely allied with *C. salina*" from which it differs in the morphology of calyx and corolla, infrastaminal scales reduced to dentate wings, and multiseeded

capsules. Beliz (1986) originally treated *C. suksdorfii* as a variety of *C. salina*, but later (1993) she included it as a synonym of *C. californica* var. *breviflora*, together with *C. occidentalis* and *C. brachycalyx*. Indeed, *C. suksdorfii* shares some characteristics with both *C. salina* (e.g., presence of infrastaminal scales as well as seed and pollen morphology—see descriptions) and *C. californica*/*C. occidentalis* (e.g., multiseeded capsules), but we consider that treating it at specific rank better represents the differences in morphology and biology as well as the evolutionary relationships between all the taxa involved (see below). *Cuscuta suksdorfii* var. *subpedicellata* Yuncker with flowers sessile or subsessile, shorter calyx (1.6–2 mm long) and capsule globose to depressed globose, is treated formally at varietal rank.

Cuscuta californica and C. occidentalis.—By describing *C. brachycalyx*, Yuncker (1932, 1965) obscured the already tenuous distinction between *C. californica* and *C. occidentalis*. Although homotypic, *C. californica* var. *brachycalyx* Yuncker and *C. brachycalyx* have slightly different protologues. *Cuscuta californica* var. *brachycalyx* has "corolla campanulate, lobes ... shorter than the tube ..." (Yuncker 1921, p. 62); *C. brachycalyx* has "corolla campanulate-globose, saccate between the stamen attachments, lobes ... shorter than or about equaling the tube" (Yuncker 1932, p. 159) and "is closely related to *C. californica*, but differs by its very short calyx and more obtuse perianth lobes." Yuncker did not mention the saccate corolla that would separate *C. brachycalyx* from *C. californica* but that would bring it close to *C. occidentalis*. Not surprisingly, Beliz (1986) concluded that "all names proposed for the numerous perianth and anther size variants within *C. californica* do not warrant taxonomic recognition ...," and she included both *C. occidentalis* and *C. brachycalyx* as synonyms of *C. californica* var. *breviflora* (Beliz 1986, 1993). We find that indeed two different major entities, corresponding to *C. californica* and *C. occidentalis*, can be distinguished in most cases, based on a combination of characters. Plants called *C. brachycalyx* by Yuncker, with a short calyx and a long (ca. 2.5 mm) campanulate corolla tube that may become somewhat saccate in fruit, possess all the characteristics of *C. californica* (see below). Although such plants are occasionally distinct, at other times the calyx/corolla tube ratio may vary even on the same plant, from flowers with calyx ca. equaling the corolla tube to flowers with calyx ca. 1/2 of the corolla tube length (Fig. 1 a, b, c). Apparently the corolla tube may continue to grow from the beginning of anthesis until fructification, significantly altering the ratio between calyx and corolla tube lengths. Similar infraspecific variation of the ratio between calyx and corolla tube lengths may be encountered in *C. gronovii* (between var. *gronovii* and var. *latiflora* Engelm.), but here the entities are relatively discrete (Costea et al. 2006b). For these reasons, *C. brachycalyx* is here considered conspecific with *C. californica* and not recognized at any rank.

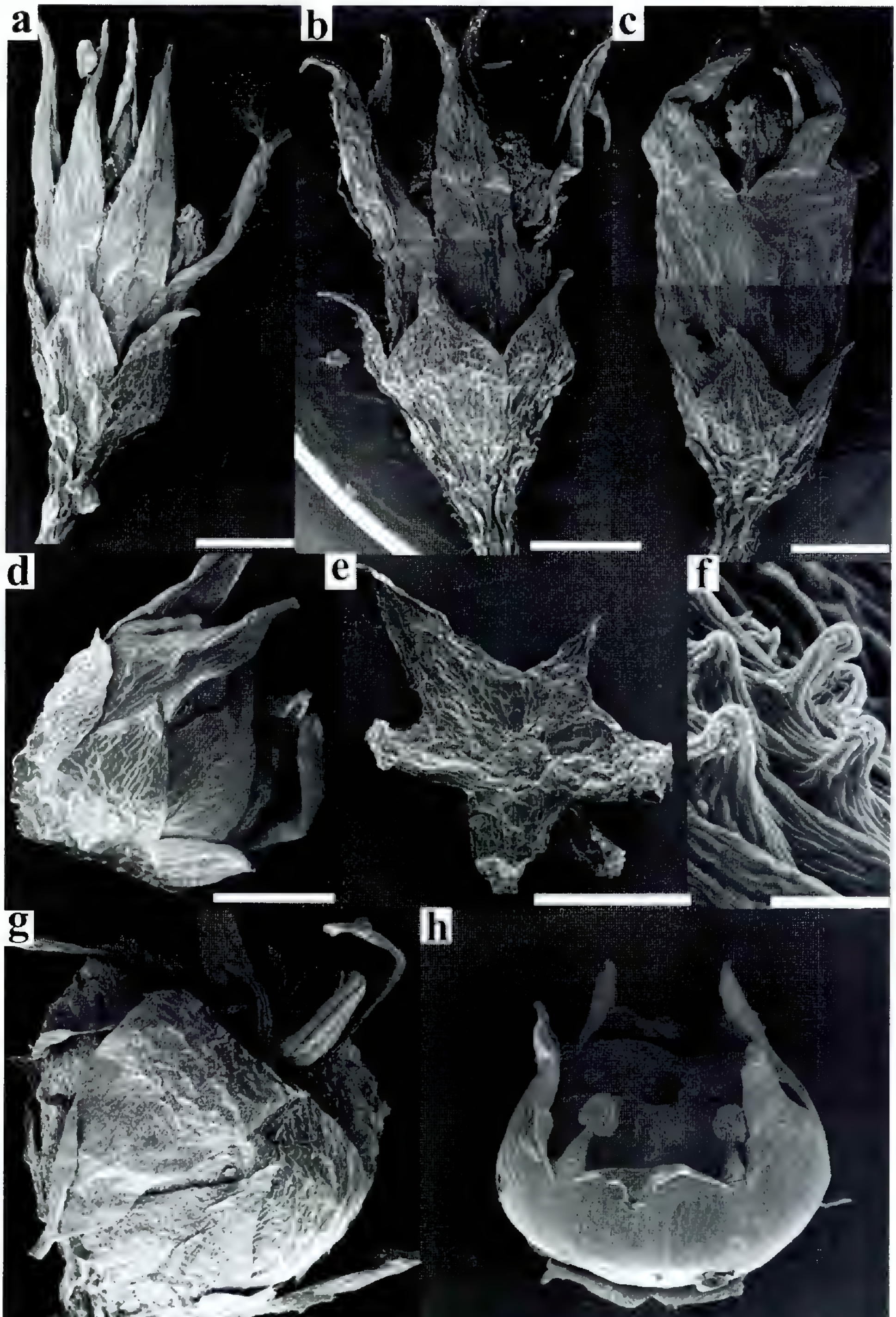


FIG. 1. Morphology of flowers and capsules. **a–c.** *Cuscuta californica* var. *californica*. Variation of corolla tube length in flowers of the same individual (scale bar = 1mm). **d.** *C. occidentalis*—flower (scale bar = 1 mm). **e.** *C. suksdorfii* – calyx (scale bar = 0.75 mm). **f.** Papillae on corolla of *C. howelliana* (scale bar = 7 μm). **g–h.** Capsules surrounded by corolla: **g.** *C. californica*, **h.** *C. occidentalis* (scale bar = 1mm).

Some plants of this complex produce a short (1.5–2 mm), campanulate-globose corolla tube (as in *Cuscuta occidentalis*) and long anthers/styles (as in *C. californica*), or plants may show reversed character states (corolla tube long and campanulate and anthers/styles short). Such intermediate-like plants occur at a frequency of ca. 1–2% of specimens examined. It is unclear if they are result of hybridization, which has never been clearly documented in *Cuscuta*, or evidence of variation in closely related and incompletely differentiated taxa. Because such possibly intermediate plants are relatively few, and to avoid nomenclatural changes, we maintain *C. californica* and *C. occidentalis* as distinct species. Several varieties within *C. californica* usually can be distinguished, based on single characters. *Cuscuta occidentalis* is less variable; a few collections were found to possess papillose flowers like *C. californica* var. *papillosa*, but the origin of this variation is unclear.

KEY TO SPECIES OF THE *CUSCUTA SALINA-CALIFORNICA* COMPLEX

1. Infrastaminal scales present (sometimes reduced to ridges), fimbriate.
   2. Flowers 5–7(–9) mm long; calyx ca. 1/2 of the corolla tube, with lobes overlapping at base; corolla lobes 1/4–1/3 as long as the tube; anthers 0.8–2 mm long _____ **3. C. subinclusa**
   2. Flowers 2.8–5(–6.) mm long; calyx ca. equaling or somewhat longer than corolla tube, with non-overlapping lobes; corolla lobes ± equaling the tube; anthers 0.3–0.7 mm long.
      3. Flowers 5-merous; calyx and corolla lobes acute to acuminate; capsules elliptical-ovate, ± thickened around the interstylar aperture, with 1 seed _____ **1. C. salina**
      3. Flowers 4- and 5-merous; at least some calyx and corolla lobes in the same flower long-attenuate; capsules globose to slightly depressed, not thickened apically, with 1–4 seeds _____ **2. C. howelliana**
1. Infrastaminal scales comp etely absent or represented by lateral, dentate wings.
   4. Flowers 4–5-merous; calyx and corolla lobes long acuminate; infrastam inal scales represented by lateral, dentate wings; withered corol.a surrounding capsule in the lower half _____ **4. C. suksdorfii**
   4. Flowers 5-merous; calyx and corolla lobes acute but not acuminate; infrastaminal scales completely absent; withered corolla completely enveloping the capsule or leaving only its top visible.
      5. Flowers short-pedicellate; corolla not saccate between the stamen attachments (if slightly saccate then with all the following characteristics); styles 1.2–3 mm long; anthers oblong to linear, 0.7–1.1 mm long; capsule completely enclosed by corolla (top not visible); seeds not visible through the corolla and pericarp, which are thicker, not semitransparent _____ **5. C. californica**
      5. Flowers sessile or subsessile; corolla saccate between the stamen attachments; styles 0.5–1(–1.5) mm; anthers broadly-elliptic, 0.25–0.5 mm long; capsule not completely enclosed by corolla (at least the top of capsule is visible); seeds visible through the thin and semitransparent corolla and pericarp _____ **6. C. occidentalis**

1. Cuscuta salina Engelm. in W.H. Brewer, S. Watson, & A. Gray, Bot. Calif. 1:536. 1876. *Grammica salina* (Engelm.) Taylor & MacBryde, Canad. J. Bot. 56:186. 1978. LECTOTYPE

(Yuncker 1932): U.S.A. UTAH: Rio Virgen, on *Suaeda*, saline soil, Nov 1885, *Remy s.n.* (MO, fragment NY). This was essentially a renaming at specific rank (as "**C. salina**, Engelm. n. sp.") of what Engelmann had earlier published as *C. subinclusa* var. *abbreviata* and *C. californica* var. *squamigera*—both varieties were cited in synonymy. Yuncker (1932) specifically referred to the MO specimen ("Remy, in the herbarium of the Missouri Botanical Garden") as the type of *C. salina*.

Stems slender, orange-yellow. **Inflorescences** umbellate cymose clusters; pedicels 0.5–2.5 mm long; bracts 1(–0), ovate-lanceolate to lanceolate. **Flowers** 5-merous, white, 2.5–5(–6.2) mm long; papillae present or absent in the corolla; laticifers conspicuous in the perianth, ovary and capsule. **Calyx** campanulate to narrow-campanulate, about as long as the corolla tube, divided ca. 1/2 the length, glossy yellow or brownish when dried, lobes ovate-lanceolate, acute to acuminate, ± unequal, not basally overlapping or slightly so. **Corolla** 2.4–4.8(–6) mm long; tube cylindric-campanulate to campanulate, 1.2–2.5 mm long, lobes ovate-lanceolate, acute to acuminate, ca. as long as the tube, erect to spreading, sometimes basally overlapping. **Stamens** included or exerted, anthers elliptical, 0.3–0.7 mm long, filaments equaling to longer than anthers. **Pollen** 3(–4)-zonocolpate 19–22(–26) µm, polymorphic, subsphaerical to subprolate, rounded at poles, tectum perforatum, puncta, 0.3–0.5 µm in diameter, granulate (Fig. 2a). **Infrastaminal scales** oblong, short-fringed, rarely reduced to sparingly fringed ridges ca. 1/2–2/3 the corolla tube length. **Styles** distinct, 0.4–1 mm long; stigmas capitate, globose. **Capsules** elliptical-ovate, 2–3.6 × 1.4–2.1 mm, ± thickened around the interstylar aperture, indehiscent or irregularly dehiscent, surrounded or capped by the withered corolla. **Seeds** 1 per capsule, not visible through the persistent corolla and pericarp, 1.35–1.57 × 1.25–1.43 mm, ± dorsoventrally compressed, broadly elliptic to subround, hilum subterminal, subround, 0.11–0.14 × 0.7–0.11 mm, vascular scar linear, 0.02–0.05 mm, oblique; surface of seed coat epidermis alveolate when dried and papillate when hydrated, cells 30–40 µm in diameter. ***n*** = 14 (Beliz 1986); ***2n*** = 30 (Pazy & Plitmann 1995).

KEY TO VARIETIES OF *CUSCUTA SALINA*

1. Papillae present on pedicels, calyx and/or corolla; infrastaminal scales represented by narrow, sparingly fringed ridges _____ **1c. C. salina** var. **papillata**
1. Papillae absent; infrastaminal scales narrowly oblong, few-toothed.
   2. Corolla 2–3.5 mm; inland salt flats _____ **1a. C. salina** var. **salina**
   2. Corolla 3–4.8(–6) mm; coastal salt marshes, tidal flats _____ **1b. C. salina** var. **major**

1a. Cuscuta salina var. **salina**. *Cuscuta subinclusa* var. *abbreviata* Engelm., Trans. Acad. Sci. St. Louis 1:500. 1859. TYPE: U.S.A. CALIFORNIA. [Solano Co.]: Mare Island in San Francisco Bay, on *Arthrocnemum*, *Wright s.n.* (HOLOTYPE: MO).

Cuscuta californica Hook. & Arn. var. *squamigera* Engelm., Trans. Acad. Sci. St. Louis 1:499. 1859. *Cuscuta salina* var. *squamigera* (Engelm.) Yuncker, Illinois Biol. Monogr. 6, pt. 2–3:71, fig. 126. 1921. *Cuscuta squamigera* (Engelm.) Piper, Contr. U.S. Natl. Herb. 11:455. 1906. TYPE: U.S.A. UTAH: Rio Virgen, on *Suaeda*, saline soil, Nov 1855, *J. Remy s.n.* (HOLOTYPE: P; ISOTYPE: MO, fragment NY). Engelmann's protologue specifically noted "*J. Remy*! in Hb. Mus. Paris." Yuncker (1921) described the type of var. *squamigera* as "Rio Virgen, (Remy in 1855, ... a fragment in the En-

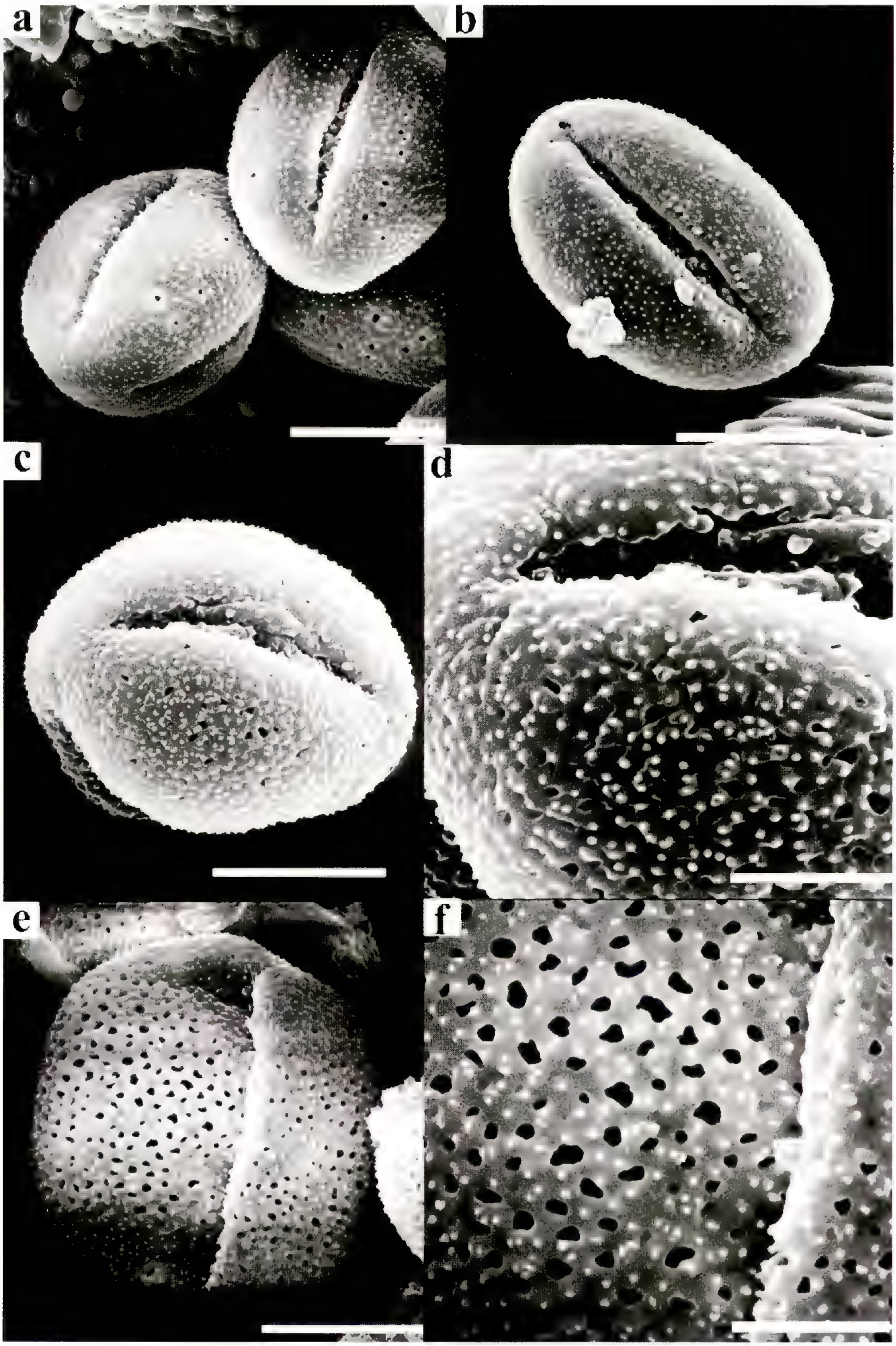


Fig. 2. Morphology of pollen. **a.** *Cuscuta salina* (scale bar = 10 μm). **b.** *C. occidentalis* (scale bar = 10 μm). **c.–d.** *C. howelliana* (scale bar = 10 and 3 μm, respectively). **e–f.** *C. subinclusa* (scale bar = 10 and 3 μm, respectively).

gelmann Herb.)."

Distribution and ecology.—**CANADA:** British Columbia. **U.S.A.:** Arizona, California, Nevada, New Mexico, Oregon, Utah, Washington. **MEXICO:** Baja California. Flowering Apr–Nov. **Hosts:** *Atriplex*, *Cressa*, *Centromadia*, *Jaumea*, *Plantago*, *Salicornia*, *Salsola*, *Suaeda*, *Trichostema*, *Wislizenia*, in inland salt flats, marshes, ponds.

Conservation status.—T4 (apparently secure) (not yet assessed by NatureServe 2005).

1b. Cuscuta salina var. **major** Yuncker, Illinois Biol. Monogr. 6:161. 1921. TYPE: U.S.A. CALIFORNIA. Santa Clara Co.: Palo Alto, frequent on *Salicornia* in the marshes, 14 Sep 1901, *Baker 41* (HOLOTYPE: NY; ISOTYPES: CAS, GH, RSA).

Distribution and ecology.—**CANADA:** British Columbia. **U.S.A.:** California, Oregon, Washington. Flowering Jul–Oct. **Hosts:** various species, especially *Salicornia*, in coastal salt marshes, tidal flats.

Conservation status.—T3T4 (vulnerable to apparently secure) (not yet assessed by NatureServe 2005).

1c. Cuscuta salina var. **papillata** Yuncker, Bull. Torrey Bot. Club 69: 543. 1942. TYPE: U.S.A. CALIFORNIA. Mendocino Co.: Fort Bragg, 8-16 Aug 1912, *Eastwood 1593* (HOLOTYPE: GH, fragment NY).

Distribution and ecology.—**U.S.A.:** Arizona, California, Utah. Flowering Jun–Oct. **Hosts:** various species in salt marshes, flats, ponds.

Conservation status.—T3T4 (vulnerable to apparently secure) (not yet assessed by NatureServe 2005).

2. Cuscuta howelliana Rubtzoff, Leafl. W. Bot. 10:335. 1966. TYPE: U.S.A. CALIFORNIA. Lake Co.: Boggs Lake, open dry margin of the lake, inundated in winter, 20 Aug 1966, *Rubtzoff & Arnaud 5792* (HOLOTYPE: CAS, ISOTYPES: CAS, GH, OSC, RSA, UC).

Stems slender, yellow to orange. **Inflorescences** few- to many-flowered ± glomerulate cymes, pedicels 0–0.6 mm long; bracts 1–0, lanceolate. **Flowers** embedded in the inflorescence of the host, 4–5-merous, 3–4.5 mm long, whitish, papillate-glandular. **Papillae** present in the calyx and corolla; elongated laticifers present in the calyx and corolla but not obvious (Fig. 1f). **Calyx** campanulate, ca. equaling corolla tube or exceeding it, divided 1/2–2/3 to the base, lobes unequal, triangular-ovate, acute, acuminate to long-attenuate and recurved at the apex, non-overlapping. **Corolla** tube cylindrical-campanulate, later more or less urceolate, ca. 1.5–2.2 mm long, lobes unequal, ca. equaling the tube, triangular-ovate, with acute to long-attenuate, recurved tips, suberect to spreading. **Stamens** included, anthers elliptical, 0.4–0.7 mm long; filaments 0.1–0.4 mm long. **Pollen** 3(–4)-zonocolpate (15–)17–22(–24) µm, polymorph, sphaerical to subprolate (subsphaerical more common), rounded at poles, tectum perforatum to microreticulate, puncta, 0.4–0.8 µm in diameter, granulate (Fig. 2 c, d).

Infrastaminal scales oblong-ovate, fringed, reaching to about the middle of the corolla tube; **Styles** distinct, evenly filiform, 0.4–1.1 mm; stigmas capitate, globose. **Capsules** globose to slightly depressed, 1.2–1.5 × 0.8–1.2 mm, not thickened apically, indehiscent or irregularly dehiscent, completely enclosed by the withered corolla and latter capped by it. **Seeds** 1–4 per capsule visible through the semi-transparent corolla and pericarp, 0.9–1.43 × 0.8–1.3 mm, dorsoventrally compressed to slightly angled, subround to broadly-elliptic, hilum subterminal, scar area clearly differentiated from the rest of the seed, broadly elliptic 0.21–0.25 × 0.12–0.15 mm, hilum linear 0.05–0.06 mm, vertical; heterogeneous; some areas are alveolate with cells 35–50 µm in diameter; some areas irregularly wrinkled (Fig. 3 c, e, f, g). ***2n*** = 26 (Beliz 1986).

Distribution and ecology.—**U.S.A.:** Endemic in California. Flowering Aug–Sep. **Hosts:** mostly *Eryngium aristulatum*, *E. vaseyi*, *E. castrense*, *E. alismaefolium*, *Navarretia leucocephala*, and *N. minima*, but also on *Polygonum kelloggii*, *Epilobium pygmaeum*; margins of vernal pools.

Conservation status.—G2G3 (imperiled to vulnerable) (G3, NatureServe 2005).

The biology of this species deserves future study. The parasite becomes strictly localized to the inflorescence region of the host. Flowers of *C. howelliana* develop inside the dense host inflorescences and apparently synchronize their anthesis with that of the host's flowers. The parasite achieves both protection and proximity to the flux of assimilates intended for the development of host's reproductive structures.

3. Cuscuta subinclusa Durand & Hilgard, J. Acad. Nat. Sci. Philad. ser. 2, 3:42. 1855. TYPE: U.S.A. CALIFORNIA. [Los Angeles Co.]: Tejon Pass, on a willow, *Heermann s.n.* (HOLOTYPE: PH presumably, fragment MO).

Cuscuta ceanothi Behr, Proc. Calif. Acad. (ed. 2) 1:16. 1854. The protologue gave no information regarding a type, and a neotypification probably will be required to firmly establish the identity of this name (see comments above). *Cuscuta ceanothi* is the earlier name but is tentatively placed here with *C. subinclusa*.

Stems medium, sometimes fleshy, creamy. **Inflorescences** few- to several-flowered, in scattered to densely aggregated clusters; pedicels 0–1 mm long; bracts 1-0, ovate to lanceolate. **Flowers** 5-merous, 5–7(–9 mm) long, white. Papillae present in the corolla lobes; laticifers isolated or in rows obvious in the calyx, corolla and fruit. **Calyx** campanulate, ca. 1/2 as long as the corolla tube, divided 3/5–2/3 the length, lobes broadly ovate to lanceolate, acute, sometimes cuspidate, basally overlapping. **Corolla** tube cylindric, 2.5–3.5(–4.5) mm long, usually showing horizontal ridges between the stamen attachments when dry, lobes ovate-triangular, acute and often slightly acuminate, 1/4–1/3 as long as the tube, widely spreading to reflexed. **Stamens** subincluded; anthers linear 0.8–2 mm; filaments 0–0.1 mm. **Pollen** 3(–4)-zonocolpate (15–)17–22(–24) µm long, polymorph, subsphaerical to subprolate, rounded at poles, tectum microreticulate,

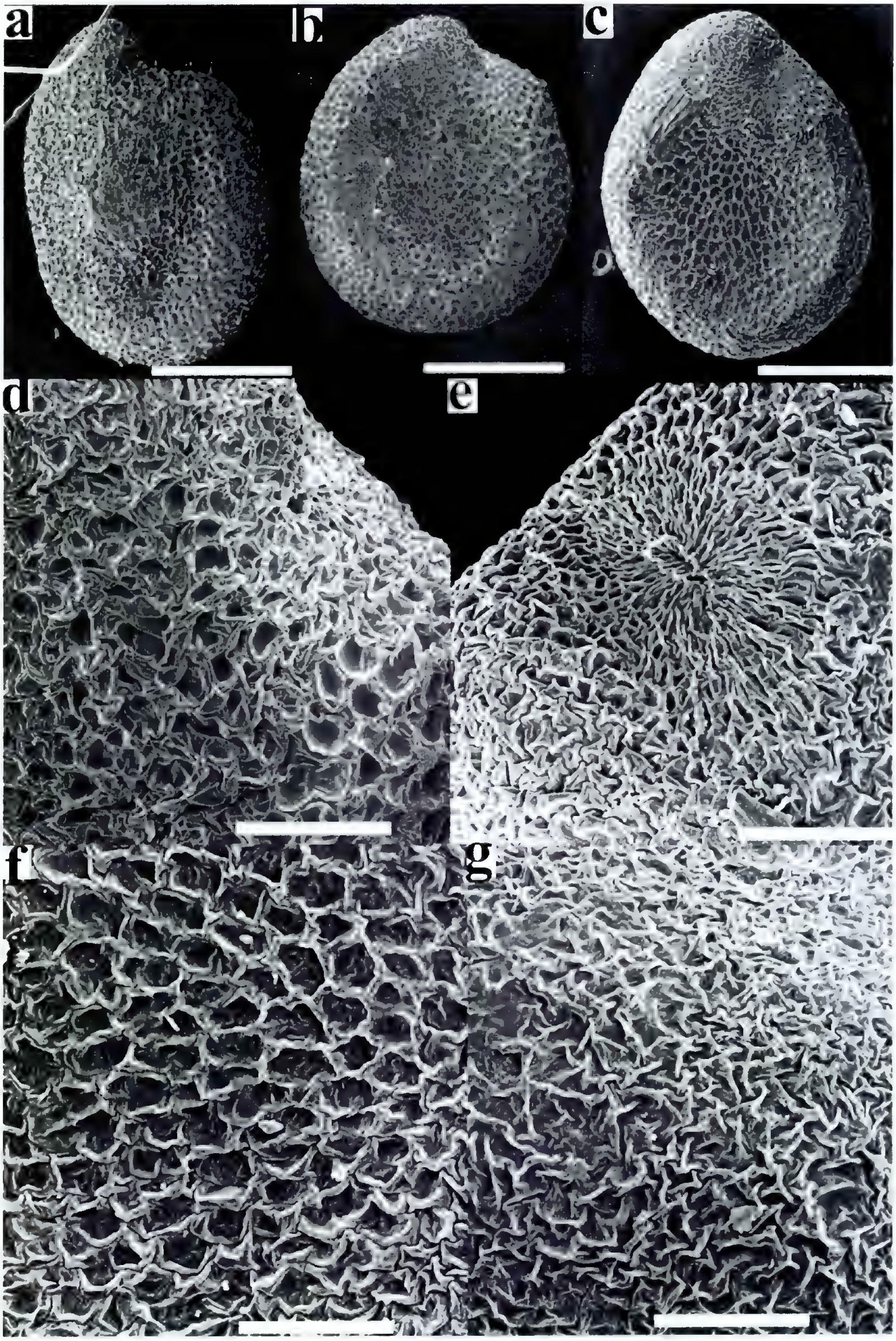


FIG. 3. Morphology of seeds. **a.** *C. californica* (var. *californica*), lateral view. **b.** *C. occidentalis*, lateral view. **c.** *C. howelliana*, lateral view (scale bar = 0.38 mm). **d.** Hilum of *C. californica*. **e–g.** *C. howelliana*: **e.** hilum, **f–g.** variation of seed coat micromorphology (scale bar = 100 μm).

puncta, 0.4–0.9 µm in diameter, granulate (Fig. 2 e,f). **Infrastaminal scales** oblong to spatulate, irregularly short-fimbriate, ca. 1/2 as long as the corolla tube; styles 1–1.5 mm long; stigmas capitate, globose. **Capsules** ovate to elliptical, 1.5–3 × 1.2–2.5 mm, pointed, thickened in the form of a collar about the interstylar aperture, indehiscent or irregularly dehiscent, capped by the withered corolla. **Seeds** mostly 1 per capsule, not visible through the capsule, subglobose to broadly ovoid, rarely slightly dorsoventrally compressed, 1.3–1.7 × 1.2–1.5 mm; hilum terminal; seed coat cells alveolate/papillate when dried and papillate when hydrated, cells 30–40 µm in diameter. ***n*** = 14 (Beliz 1986).

Distribution and ecology—**U.S.A.:** California, Oregon. **MEXICO:** Baja California. Flowering Apr–Oct. **Hosts:** wide variety of woody and sometimes herbaceous plants growing along river banks and canyon bottoms, sometimes in salt marshes and deserts, including species of *Adenostoma*, *Amelanchier*, *Arctostaphylos*, *Artemisia*, *Asclepias*, *Ceanothus*, *Cercis*, *Citrus*, *Clematis*, *Erigeron*, *Grindelia*, *Heteromeles*, *Monardella*, *Rhus*, *Schinus*, *Populus*, *Rhododendron*, *Rosa*, *Salix*, *Solidago*, *Vitis*, particularly common on *Rhus* and *Eriogonum*.

Conservation status.—G4 (apparently secure) (not yet assessed by NatureServe 2005).

4. Cuscuta suksdorfii Yuncker, Mem. Torrey Bot. Club 18:167. 1932. TYPE: U.S.A. WASHINGTON. Skamania Co.: on an island of a mountain lake, on *Aster*, 24 Sep 1891, *Suksdorf 1487* (HOLOTYPE: US, fragment NY; ISOTYPES: GH, NY-2 sheets). This was essentially a renaming at varietal rank of *Cuscuta salina* var. *acuminata* (see below), but apparently Yuncker intended for it to be taken as a homotypic new species.

Stems slender, yellow. **Inflorescences** few-flowered umbellate clusters; pedicels 0–2 mm long; bracts 0–1, ovate lanceolate. **Flowers** 4–5-merous, white, 2.8–3.3 mm long; papillae absent; laticifers isolated in the calyx, corolla and ovary/capsule. **Calyx** broadly campanulate often zygomorphic, reaching ca 1/2 to the corolla lobes tips, divided 1/2–3/5, lobes ovate more or less unequal, with long-attenuate tips, not basally overlapping (Fig. 1e). Corolla 2.9–3.2 mm long; tube campanulate, 1.2–1.5 mm, lobes triangular-ovate, with lanceolate-attenuate tips, longer than the tube, suberect. **Stamens** included or barely visible through the corolla sinuses, anthers broadly elliptic, 0.2–0.4 mm long, filaments longer than anthers. **Pollen** 3(–4)-zonocolpate 18–22(–24) µm, polymorph, subsphaerical to subprolate, rounded at poles, tectum perforatum, puncta, 0.3–0.5 µm in diameter, granulate. **Infrastaminal scales** oblong, represented by shallowly toothed wings, 1/2–3/4 as long as the corolla tube; styles distinct, terete to slightly subulate, 0.3–0.7 mm long; stigmas capitate, globose. **Capsules** elliptical-ovoid, ovoid-conic, globose to depressed globose, 2–3.2 × 2–3.6 mm, irregularly dehiscent, with withered corolla surrounding lower half. **Seeds** 2–4 per capsule, 0.80–1.1 × 0.8–1.02 mm, dorsoventrally compressed, subround, hilum subterminal, 0.25–0.3 × 0.2–0.28 mm, vascular scar, 0.04–0.07 mm, oblique; alveolate when dry and papillose when hydrated, cells 30–50 µm in diameter. ***n*** = 14 (Beliz 1986).

KEY TO VARIETIES OF *CUSCUTA SUKSDORFII*

1. Flowers on pedicels 0.5–2 mm; calyx 2.2–2.6 mm long; capsule globose to ovoid-conic _____ **4a. C. suksdorfii** var. **suksdorfii**
1. Flowers sessile or subsessile; calyx 1.6–2 mm long; capsule globose to depressed globose _____ **4b. C. suksdorfii** var. **subpedicellata**

4a. Cuscuta suksdorfii var. **suksdorfii.** *Cuscuta salina* var. *acuminata* Yuncker, Illinois Biol. Monogr. 6, pt. 2, 3:72, fig. 32, 89. 1921 (non *C. acuminata* Nutt. ex Engelm. 1859, in adnot.). TYPE: U.S.A. WASHINGTON. Skamania Co.: on an island of a mountain lake, 24 Sep 1891, *Suksdorf 1487* (HOLOTYPE: US, fragment NY; ISOTYPES: CAS, GH, MO, NY-2 sheets).

Distribution and ecology.—**U.S.A.:** California, Oregon, Washington. Flowering Jul–Sep. **Hosts:** herbaceous species, mostly Asteraceae, *Calyptridium, Trifolium.* Mountain meadows, 5000–8500 ft.

Conservation status.—G2G3 (imperiled to vulnerable) (the same assessment in NatureServe 2005).

4b. **Cuscuta suksdorfii** var. **subpedicellata.** *Cuscuta suksdorfii* var. *subpedicellata* Yuncker, Bull. Torrey Bot. Club 62:512. 1935. TYPE: U.S.A. CALIFORNIA. Siskiyou Co.: Siskiyou Mts., Head E Fork Horse Creek, 6500 ft, S9 T47 N, R10 W, host: *Calyptridium umbellatum*, 21 Aug 1934, *L.C. Wheeler 3192* (HOLOTYPE: NY).

Distribution and ecology.—**U.S.A.:** California, Flowering Jul–Sep. **Hosts:** *Calyptridium.* Mountain meadows, 6500 ft.

Conservation status.—G2G3 (imperiled to vulnerable) (the same assessment in NatureServe 2005).

5. Cuscuta californica Hook. & Arn., Bot. Beechey Voy., 364. 1839 (non Choisy 1842). TYPE: Presumably in K, not designated by Hooker and Arnott. Engelmann (1859) commented that "Both [Choisy and Hooker & Arnott] described this plant from Douglas's specimens under the same name and in the same year (1841)." De Candolle (Prodr. vol. 9, 1845, p. 457) cited "hab. Nov. Californiam ubi rep. Douglas! h. soc. hort. Lond. Hook. bot. Beech. suppl. p. 364." Yuncker (1921, 1932) apparently repeated de Candolle's citation, noting for the type "'Nov. Californiam' (*Douglas*). Not seen."

Stems medium, yellow to orange. **Inflorescences** loose, cymose-paniculate clusters; pedicels (0.5)1–2.5(–3 mm); bracts lanceolate to ovate. **Flowers** 5-merous, white, 3–5(–6.5) mm long; papillae sometimes present on the pedicels, receptacle, calyx and corolla; laticifers isolated, elongated present in the corolla and capsules. **Calyx** turbinate-campanulate, sometimes together with the receptacle, fleshy at the base, 1/2 to ca. as long as the corolla tube, divided 1/2–1/3 to the base, lobes triangular to lanceolate, acute to acuminate, basally overlapping. **Corolla** persistent; tube campanulate-cylindric, 1.9–2.7 mm, sometimes showing horizontal ridges between the stamen attachments when dry, rarely somewhat saccate, lobes narrowly lanceolate, acute, shorter than, equaling or longer than the tube, initially erect, later reflexed (Fig. 1 a, b, c). **Stamens** ± exerted when flowers are completely open, anthers oblong to linear, 0.7–1.1 mm long, filaments 0.1–1.1 mm long. **Pollen** 3(–4)-zonocolpate (16–)17.5–22.6(–26) µm, polymorph, sphaerical to pro-

late (the latter more common), rounded at poles, tectum imperforatum or with a few puncta, 0.2–0.3 µm in diameter, granulate. **Infrastaminal scales** completely lacking or reduced, 0.1 mm long at the base of the corolla tube. **Styles** distinct, evenly filiform, 1.2–3 mm long, stigmas capitate, globose. **Capsules** globose or ovoid-conic, 1.6–2.3 × 1.8–2.5 mm, sometimes apically pointed, indehiscent or irregularly dehiscent, completely hidden by the withered corolla (Fig. 1g); pericarp and persistent corolla not semi-transparent (thicker than in *C. occidentalis*). **Seeds** 1–4 per capsule, not visible through the persistent corolla and pericarp, 0.90–1.4 × 0.85–1.2 mm, dorsoventrally compressed, broadly-elliptic to obovate, hilum lateral, inconspicuous, subround 0.10–0.15 mm, vascular scar 0.05–0.06 mm, vertical; entirely alveolate (hilum area included) when dry and papillose when hydrated, cells 25–50 µm in diameter (Fig. 3a, d). ***n*** = 14 (Beliz 1986).

In some plants of *Cuscuta californica* (particularly of vars. *apodanthera* and *apiculata*), the receptacle and perianth cells located at the base of capsules and seeds are fleshy and become mucilaginous when brought in contact with water. A similar phenomenon occurs in *C. nevadensis* I.M. Johnston and to a lesser extent in *C. veatchii* Brandegee; Costea et al. 2005 suggest these features may be related to vivipary observed in *C. nevadensis*. The fleshy receptacle and perianth base in *C. californica* may be homologous with those of *C. nevadensis*, but in contrast to *C. nevadensis*, *C. californica* does not have seeds with a globular-enlarged embryo at the hilum end. Apart from scattered observations such as these, the reproductive biology of *Cuscuta* species is poorly known (reviewed by Dawson et al. 1994; Costea & Tardif 2006).

KEY TO VARIETIES OF *CUSCUTA CALIFORNICA*

1. Ovary and fruit conic, apically pointed; 1-seeded _____ **5b. C. californica** var. **apiculata**
1. Ovary and fruit globose to globose depressed; (1–)2–4 seeded.
   2. Flowers and pedicels densely papillate _____ **5c. C. californica** var. **papillosa**
   2. Flowers and pedicels not papillate.
      3. Anthers sessile or subsessile _____ **5d. C. californica** var. **apodanthera**
      3. Anthers not sessile, filaments shorter to equaling anthers _____ **5a. C. californica** var. **californica**

5a. Cuscuta californica var. **californica.** *Cuscuta californica* Hook. & Arn. var. *graciliflora* Engelm., Trans. Acad. Sci. St. Louis 1:499. 1859. LECTOTYPE (designated here): U.S.A. CALIFORNIA: "Almost without flowers, on *Monarda*," Fremont's Expedition to California [without other data], 1846 (MO!). Engelmann cited "California, Douglas! Fremont! 506; Bigelow!"

Cuscuta californica Hook. & Arn. var. *longiloba* Engelm., Trans. Acad. Sci. St. Louis 1:499. 1859. LECTOTYPE (designated here): U.S.A. CALIFORNIA: San Felipe, on *Eriogonum polifolium*, Jan 1852, *Thurber* 633 (MO). Engelmann cited "Sta. Barbara, Nuttall! San Diego, Thurber! 570 & 633; Newberry!" Engelmann's material (at MO) of the Nuttall collection apparently is a fragment of the original specimen at PH, judging from notes inside the packet.

Cuscuta californica Hook. & Arn. var. *brachycalyx* Yuncker, Illinois Biol. Monogr. 6, nos. 2, 3:62, fig. 45, 75. 1921. TYPE: U.S.A. CALIFORNIA: Near Hanford, dry soil on *Centromadia pungens*, 21 Jun 1901, *Kearney* 52 (HOLOTYPE: NY; ISOTYPE: US).

Cuscuta brachycalyx Yuncker, Mem. Torrey Bot. Club 18:159. 1932. TYPE: U.S.A. CALIFORNIA: Near Hanford, dry soil on *Centromadia pungens*, 21 Jun 1901, *Kearney 52* (HOLOTYPE: US). Yuncker treated this as a new species, even though he cited *C. californica* var. *brachycalyx* in synonymy.

Distribution and ecology.—**U.S.A.:** Arizona, California, Nevada, Oregon, Utah, Washington; **Mexico** (Baja California). Flowering Mar–Aug(–Sep). **Hosts:** *Abronia, Adenostoma, Agastache, Ambrosia, Asclepias, Convolvulus, Corethrogyne, Croton, Eriodictyon, Eriogonum, Holocarpha, Iva, Lupinus, Salvia*, and others. 200–22650 feet.

Conservation status.—T5 (common) (the same assessment in NatureServe 2005).

5b. Cuscuta californica var. **apiculata** Engelm., Trans. Acad. Sci. St. Louis 1:499. 1859. TYPE: U.S.A. CALIFORNIA: "Dry arroyos, on *Dalea spinosa*, [on the] Colorado," 22 Feb 1884, *J.M. Bigelow s.n.* (HOLOTYPE: MO; ISOTYPES: GH, NY).

Distribution and ecology.—**U.S.A.:** California, Nevada. **MEXICO:** Baja California. Flowering Mar–Aug. **Hosts:** various species in sandy desert areas.

Conservation status.—T1T2 (critically imperiled to imperiled), (T3?, Natureserve 2005).

5c. Cuscuta californica var. **papillosa** Yuncker, Illinois Biol. Monogr. 6:152. 1921. TYPE: U.S.A. CALIFORNIA. San Bernardino Co.: San Bernardino Valley, *Parish 5524* (HOLOTYPE: RM).

Distribution and ecology.—**U.S.A.:** California (endemic): Imperial, Riverside, San Bernadino, and San Diego cos. Flowering Mar–Aug, –Sep. **Hosts:** various species in sandy desert areas. 300–4600 feet.

Conservation status.—T3 (vulnerable) (the same assessment in NatureServe 2005).

5d. Cuscuta californica var. **apodanthera** Yuncker, Illinois Biol. Monogr. 6:152. 1921. *Cuscuta brachycalyx* var. *apodanthera* (Yuncker) Yuncker, Mem. Torrey Bot. Club 18:159. 1932. TYPE: U.S.A. CALIFORNIA: Yosemite Valley, 7–12 Jul 1896, *Jepson 80a* (HOLOTYPE: JEPS, fragment NY).

Distribution and ecology.—**U.S.A.:** Endemic in California. Flowering Aug–Sep. **Hosts:** *Eriogonum* and other herbs.

Conservation status.—T1T2 (critically imperiled to imperiled) (T2, NatureServe 2005).

6. Cuscuta occidentalis Millsp. [nom. nov.], Publ. Field Columbian Mus., Bot. Ser. 5:204. 1923. Based on *Cuscuta californica* Hook. & Arn. var. *breviflora* Engelm., Trans. Acad. Sci. St. Louis 1:499. 1859. *Grammica occidentalis* (Millsp.) Hadac & Chrtek, Folia Geobot. Phytotax. 8:220. (Aug) 1973. *Grammica occidentalis* (Millsp.) W.A. Weber, Southw. Naturalist 18:319. (Oct) 1973. TYPE: U.S.A. CALIFORNIA. Monterey Co.: Monterey, in fields, [no date], *Hartweg 1863* (HOLOTYPE: MO; ISOTYPES: GH, NY).

Stems medium, yellowish to orange. **Inflorescences** compact glomerulate clusters; pedicels 0–0.5(–1.5 mm); bracts lanceolate to ovate. **Flowers** 5-merous, white

to creamy; 2.7–3.4 mm long; papillae rarely present; laticifers not conspicuous (Fig. 1d). **Calyx** campanulate, somewhat shorter to ca. as long as the corolla tube, divided 2/5–1/2 the length, rarely fleshy at base, lobes narrowly ovate to lanceolate, acuminate, not basally overlapping; corolla tube cylindric-campanulate, 1.4–2.1 mm long, saccate between the stamen attachments, lobes lanceolate, acuminate, shorter than the tube, initially erect, later usually spreading (sometimes reflexed) giving flowers a star-shaped appearance. **Stamens** ± exserted; anthers broadly-elliptic, 0.25–0.5 mm long, filaments 0.3–1 mm long. **Pollen** as in *C. californica*, (17–)19–24(–26) µm long. **Infrastaminal scales** as in *C. californica*; styles distinct, evenly filiform, styles 0.5–1(–1.5) mm long; stigmas capitate, globose. **Capsules** globose to globose-depressed, 1.8–2.2 × 2–2.6 mm, indehiscent or irregularly dehiscent, not completely enclosed by the corolla (the top of capsule visible) (Fig. 1h); corolla and pericarp thin, membranous and semi-transparent. **Seeds** 2–4 per capsule, visible through both corolla and pericarp, 0.85–1.3 × 0.8–1.1, dorsoventrally compressed, subround to broadly-elliptic, hilum subterminal, poorly differentiated from the rest of the seed, subround 0.10–0.15 mm, vascular scar 0.05–0.06 mm, vertical, surface of seed coat alveolate when dry (including hilum area), cells 25–50 µm in diameter (Fig. 3b).

Distribution and ecology.—**U.S.A.:** California, Colorado, Idaho, Nevada, Oregon, Utah, Washington, Wyoming. **MEXICO:** Baja California. Flowering Mar–Aug(–Sep). **Hosts:** *Artemisia, Boisduvalia, Calyptridium, Corethrogyne, Ericameria, Eriogonum, Hemizonia, Iva, Lotus, Lupinus, Monardella, Oenothera, Polygonum, Salvia, Sisymbrium*, and others. 25–6500 feet.

Conservation status.—G4G5 (apparently secure to secure) (not assessed yet by NatureServe 2005).

APPENDIX 1.—VOUCHERS FOR THE SEM STUDY

Vouchers are from NY unless otherwise indicated.

1. Cuscuta salina (see Costea et al. 2005).

2. Cuscuta howelliana (7 collections examined).—**U.S.A. CALIFORNIA. Butte Co.:** ca 7 mi N of Oroville, N Table Mountain, E side of Cherokee Rd., 1325 ft, 18 Jul 1998, *Ahart 8044* (JEPS). **Sacramento Co.:** ca 1 mi S of White Rock Rd. and Scott Rd. intersection, 27 May 1985, *Bowcutt 331* (UC). **Shasta Co.:** between Goose Valley and Burney Valley, ca. 3.5 mi NNW from Burney, 3200 ft, 8 Aug 1988, *Taylor 10026* (JEPS). **Siskiyou Co.:** 16 mi N of Fall River Mills (Shasta Co.) and 6 mi W of Day (Modoc Co.), 1.2 mi E of Spring Creek Rd., 3600 ft, 19 Jul 1989, *Powell 3533* (JEPS). **Tehama Co.:** ca 10 mi SE of Corning, S Fork Hall Creek, 460 ft, 12 May 1995, *Taylor 14897* (JEPS); BLM parcel along Hwy 36 NE of Red Bluff, 870 ft, 8 Jul 1996, *Oswald & Ahart 7978* (JEPS); Inks Creek, ca. 1.5 mi N of Dales Lake, 612 ft, 27 May 1992, *Taylor 12661* (UC).

3. Cuscuta subinclusa (11 collections examined).—**U.S.A. CALIFORNIA.** [no county given, **Los Angeles or San Bernardino Co.?**] Swartout, 1 Sep 1939, *Grace s.n.* **Los Angeles Co.:** Liebre Mts., entrance to Ruby Canyon of Forest Service Rd., ca. 1/10 mi from junction with Lake Hughes Rd., 2000 ft, 23 Oct 1996, *Raz & Boyd 015*; Lower Spunky Canyon, stretch draining SSE exiting into Bouquet Reservoir, 2995–3065 ft, 20 Sep 1994, *Ross & Boyd 8260*; San Gabriel Mts., Tujunga Creek,

near mouth of Canyon, 23 Aug 1937, *Ewan 11049*. **Marin Co.:** mouth of San Antonio Creek, 3 Sep 1939, *Howell 15355*; Mouth of San Gabriel Canyon, 17 Dec 1935, *Hastings s.n.*; San Antonio Slough, N of Novato, 5 ft, 3 Sep 1939, *Rose 39363*. **Monterey Co.:** Banks of San Antonio River, Santa Lucia Mts., 25 Oct 1930, *Mason 5766*. **Nevada Co.:** Banner Mt., ca. 4 mi E of Nevada City, 3900 ft, 15 Jul 1965, *True & Howell 2315*. **Plumas Co.:** Mill Creek, Jun 1877, *Austin s.n.* **San Joaquin Co.:** San Joaquin Bridge near Lathrop, 9 Sep 1892, *Brandegee s.n.*

4. Cuscuta suksdorfii (5 collections examined).—**U.S.A. CALIFORNIA. Humboldt Co.:** Trinity Summit, near Box Camp, 5000 ft, 4 Aug 1949, *Tracy 18430* (UC). **Siskiyou Co.:** Siskiyou Mts., Mt. Diablo, 1 mi E Dry Lake Lookout, 6000 ft, 31 Jul 1934, *Wheeler 3011* (JEPS);.**[Co. unspecified**] Kings Canyon National Park, Woods Creek, near base of Castle Dome, 8500 ft, 27 Jul 1948, *Bailey & Bailey 2672a* (UC). **[Co**. unspecified] ca 1/4 mi E of Yuba Gap and Hwy 80, E side of the paved road to Lake Valley Reservoir, 5840 m, 22 Jul 2002, *Ahart 9885* (JEPS). [No location, no date, no collector] (UC 23290).

5. Cuscuta californica.

5a. Cuscuta californica var. **californica** (13 collections examined).—**U.S.A. CALIFORNIA.** [locality illegible], 21 Jun 1931, *Yuncker & Welch 3748*. **Kern Co.:** "brachycalyx," 1.5 mi N of Kernville, 2670 ft, 28 Sep 1962, *Howell 38877*. **Los Angeles Co.:** Liebre Mts., Knapp Ranch at the upper end of Castaic Creek drainage in broad alluvial valley at head of Cienaga Canyon, S of Liebre Mt., 2840–3080 ft, 28 May 1997, *Boyd 9839*; [some flowers "brachycalyx"-like] Whittier Hills, S-draining tributary of Turnbull Canyon, 980–1000 ft, 15 Jun 1992, *Ross 6575*; Mount Wilson, 3000 ft, 17 Jul 1931, *Yuncker & Welch 3704, 3707*. **Orange Co.:** Santa Ana Mts., Silverado Canyon, 21 Jun 1931, *Fosberg 5143*. **Riverside Co.:** 8 mi SE of Corona, along road to Elsinore, 17 Mar 1964, *Hitchcock & Muhlick 23076*. **San Bernardino Co.:** foot hills of San Bernardino Mountains, 15 Jun 1898, *Parish s.n.* **San Diego Co.:** Jamul Valley, Jun 1875, *Palmer 439*; San Diego, Mission Hills, 14(?) May 1903, *Abrams 3462*; along Hwy 78E 5.3 Mi W of Ramona, 15 Jun 1973, *LeDoux et al. 114*; [some flowers "brachycalyx"-like] Coronado Beach, 24 Jun 1932, *Moldenke 7037*. **San Luis Obispo Co.:** Pismo, 25 Aug 1932, *Demaree 9281*. **NEVADA**. **Clark Co.:** Hells Kitchen area near Gold Butte, Devils Cove Rd., 2.9 mi S of Connoly Spring, 2400 ft, 14 May 1986, *Pinzl 7238a*.

5b. Cuscuta californica var. **papillosa** (5 collections examined).—**U.S.A. CALIFORNIA.** [no locality], Aug 1901, *Grant 4449*. **Riverside Co.:** Cathedral City, 23 Apr 1945, *Lillian s.n.*; ca. 500 ft, 27 Dec 1945, *Rose 45331*; Cathedral Canyon, 23 Dec 1946; *Rose 46300*. **San Bernardino Co.:** 1/2 mi E of Hawes Ranch, Horsethief Canyon, Mohave River tributary, 3300 ft, 17 Sep 1933, *Wheeler 2114*.

c. Cuscuta californica. var. **apiculata** (3 collections examined).—**U.S.A. CALIFORNIA. Riverside Co.:** Cathedral City, no date (probably 1945), *Blake s.n.* **NEVADA. Clarke Co.:** 4 mi SE of Muddy Peak at head of Callville Wash, 2500 ft, 28 May 1937, *LaRivers & Hancock 261*; 29 May 1937, *LaRivers & Hancock 231*.

6. Cuscuta occidentalis (14 collections examined).—**U.S.A. CALIFORNIA. Fresno Co.:** Copper Creek Canyon Creek Trail, 7200 ft, 2 Aug 1958, *Howell 34198*. **Mono Co.:** 1 mi E of Mammoth Post Office, 29 Jul 1951, *Raven 3720*. **Monterey Co.:** Point Lobos State Park, 16 Jun 1935, *Lee & Mason 9219*. **Siskiyou Co.:** along Klamath River Hwy. W of Pacific Hwy., 2000 ft, 20 Jun 1940, *Yuncker 15144*. **Trinity Co.:** Cold Springs Area, South Fork Mt., 5400 ft, 28 Aug 1941, *Parks & Tracy 11517*. **Washoe Co.:** ca 1 mi ENE of Grass Valley Reservoir, 6000 ft, 14 Aug 1991, *Schoolcraft et al. 2220*. **COLORADO. Delta Co.:** Paonia, 23 Jul 1911, *Osterhout 4602*. **IDAHO. Adams Co.:** 2 Mi S of Council, 26 Aug 1937, *Christ & Ward 8787*. **Gooding Co.:** Little City of the Rocks in the Mt. Bennett Hills N of Gooding, 28 Jul 1976, *Ertter 2027*. **NEVADA**. **Douglas Co.:** Antelope Valley at the E edge of Red Hill on the E side of Gray Hills, 4990 ft, 14 Jul 1997, *Tiehm 12257*. **Eureka Co.:** Roberts Mts., 1.7 mi N of Three Bars Ranch on the main road to Tonkin Summit, 6600 ft, 22 Aug 2002, *Tiehm 14108*. **Mineral Co.:** E slope of Wassuk Range, base of Big Indian Mt., 9500 ft, 11 Sep 1938, *Archer 7032*. **Washoe Co.:** dry bed of Ice Pond, Whittell-Audubon Area, Carson Range foothills, 5480 ft, 12 Aug 1974, *Howell et al. 50745*. **UTAH. Salt Lake Co.:** [no locality], 16 Aug 1907, *Garrett 2170*.

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Book Review

Fa-Ti Fan. 2004. **British Naturalists in Qing China: Science, Empire and Cultural Encounter.** (ISBN 0-674-01143-0, hbk.) Harvard University Press, 79 Garden St. Cambridge, MA. (**Orders:** http://www.hup.harvard.edu/; 800-405-1619; email: Contact|HUP@harvard.edu). $52.00, 238 pp, 16 illustrations, 9 1/2" × 61/4".

The Qing (Manchu) Dynasty lasted nearly 300 years (1644–1911). In the West it was the period of the Industrial Revolution, the rapid growth of scientific knowledge and discovery, and the rising imperialism of the 17th and 18th centuries. China had had its own economic revolution between the 8th and 12th centuries, but the potential of the great advances made at that time in agriculture, technology, large-scale industry, and the use of money and credit was reaching its end. So the two cultures were at different stages in the Confucian cycle of the rise and fall of states when they met.

Although the Chinese reaction to the increasing Western presence was to restrict foreign trade to a single port an enormous volume of Chinese goods (including flora and fauna) was brought to Europe. It not only affected European taste but was a great stimulus to scientific research in this area. This book, written from the viewpoint of a modern historian, traces the activities of the British naturalists within the cultural context, examining the institutional base of enterprise as well as the purposes, methods and results for each side. Because the British became predominant in the China trade, they were best able to meet the Chinese whose cooperation was essential to their work. The author insists that it is the 'mingling, hybridization, and confluence' across a variety of borders and barriers that made possible the great advances in ethno-botany, economic botany and Sinology of this period. While he does not downplay the role of British network of traders, diplomats, missionaries, professional collectors, geographers, and geologists, he gives equal (and previously unacknowledged) emphasizes to the part played by the indigenous people: the officials. merchants, compradors, ser vants, gardeners, craftsmen, artists, etc. His aim is to "explain the formation of scientific practice and knowledge in cultural borderlands during this critical period."

The book naturally divides itself into the time before and after the Opium War. Because the abrupt policy changes which followed granted Westerners generous legal and diplomatic rights and increased access to the interior of the country, there were important changes in the procedures. Both sections are extremely interesting and well- researched. An excellent index, copious notes, short biographies of the many British naturalists mentioned, maps and illustrations all add to the value of the work. *British Naturalists in Qing China* offers fresh insights into the very many aspects of Sino-British relations. It is particularly timely as China emerges as a world power.—*Ruth Ginsburg, Botanical Research Institute of Texas, Fort Worth, TX 76102-4060, U.S.A.*

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TAXONOMY OF *CUSCUTA GRONOVII* AND *CUSCUTA UMBROSA* (CONVOLVULACEAE)

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ABSTRACT

Cuscuta umbrosa is the correct name for the species often recognized as *C. megalocarpa*. It apparently intergrades in some features with *C. gronovii*, but the two are generally distinct across a broad region of sympatry. Three varieties are recognized within *C. gronovii*: var. *gronovii* is widespread; var. *latiflora* is broadly sympatric with var. *gronovii* but is maintained because relationships with *C. gronovii* var. *gronovii* and *C. cephalanthi* are not clear; var. *calyptrata* is more distinct and narrowly restricted in range, although it also is sympatric with var. *gronovii*.

RESUMEN

Cuscuta umbrosa es el nombre correcto para la especie reconocida recientemente como *C. megalocarpa*. Es ampliamente simpátrica y algo intergradada con *C. gronovii*, pero las dos especies son generalmente claras. Se reconocen tres variedades dentro de *C. gronovii*: var. *gronovii* que está muy esparcida; var. *latiflora* es ampliamente simpátrica con la var. *gronovii* pero se mantiene debido a la relación con *C. gronovii* var. *gronovii* y *C. cephalanthi* no está clara; la var. *calyptrata* es más clara y estrechamente restringida en su distribución geográfica, aunque sea también simpátrica con la var. *gronovii*.

The original concept of *Cuscuta umbrosa* Beyr. ex Hook. (1840) included *C. gronovii* Willd. ex Roem. & Schult. (1820) in typical form as well as a variant plant, based on the specimens cited in the protologue. Engelmann (1859) clarified the typification of *C. umbrosa*, distinguishing it from *C. gronovii*, and described the variant as *C. gronovii* var. *curta* Engelm. Yuncker recognized the variant taxon at specific rank, at first (1921, 1932) using the name *C. curta* (Engelm.) Rydb. but later (1943, 1965) adopting *C. umbrosa* as the earliest legitimate name. We find that recently *C. umbrosa* either has been accepted as a species under yet another name, *C. megalocarpa* Rydb. (1901) (Kartesz 1999;

Darbyshire 2003; USDA, NRCS 2004), or else it has not been recognized at any taxonomic rank (Beliz 1986–1987, in herb; Crins & Ford 1988).

Cuscuta gronovii and *C. umbrosa*, as recognized here, are similar and apparently closely related to *C. cephalanthi* Engelm. and *C. rostrata* Shuttlw. ex Engelm. & A. Gray. These four species, which were placed by Yuncker (1965) in two subsections (*Platycarpae* and *Cephalanthae*), have the same pattern of stem growth and branching: haustoria are formed as the main stem twines around the host and no tendril-like axillary branches are generated. This pattern was first observed by Dawson (1984) in *C. gronovii*. The evolutionary and taxonomic status of *C. umbrosa* is reevaluated here, especially with regard to its relationship with *C. gronovii*.

METHODS

Descriptions of morphology are based on samples from specimens from DAO, NY, and SMU (Appendix 1). Measurements and pictures were taken with a scanning electron microscope Hitachi S-570 at 15 KV. Samples were coated with 30 nm gold using an Emitech K 550 sputter coater. Terminology regarding the micromorphology of flowers, seeds and capsules, and pollen were described in detail in the first paper published in this issue (Costea et al. 2006). Conservation status was assessed using NatureServe (2005) ranks and criteria.

TAXONOMY

Yuncker (1932, 1965) characterized *Cuscuta gronovii* as having "styles about equaling the ovary or somewhat shorter," in contrast to those of *C. umbrosa*, which are "very short, about one fourth the length of the ovary." Other contrasts between these taxa emphasized by Yuncker are in the morphology of infrastaminal scales and the size of capsules and seeds. According to him, *C. umbrosa* has infrastaminal scales about half the length of the corolla tube, broad, often truncate and bifid, and capsules and seeds are larger. In contrast, *C. gronovii* has infrastaminal scales about equaling the corolla tube, oblong and not truncate or bifid, and capsules and seeds are comparatively smaller. We find that *C. gronovii* and *C. umbrosa* usually are morphologically distinguishable, but *C. gronovii* may show character states similar to *C. umbrosa* even when it occurs outside the geographical range of the latter. For example, *C. gronovii* from Ontario and Québec may occasionally have more or less truncate infrastaminal scales one-third the length of the corolla tube, or short stigmas, or comparably large seeds (Crins & Ford 1988) and capsules. Commonly only one state character of *C. umbrosa*, or rarely a combination of two (e.g., large capsules and seeds), occurs in *C. gronovii*. Such plants of *C. gronovii* may be separated from *C. umbrosa* using the character combinations in the following key. Other differences can be found in pollen morphology: *C. gronovii* has pollen grains with tectum

imperforatum or a few puncta, while *C. umbrosa* has tectum perforatum or almost microreticulate (Fig. 1).

1. Infrastaminal scales oblong, apex usually rounded, not bifid, rarely truncate, ca. reaching the filament bases, rarely ca. 1/3 of the corolla tube; styles (0.6–)1.2–2.2 mm long; capsules 2.5–4.5(–5.2) × 2–4(–5) mm; seeds 1.35–1.7(–2.4) × 1.2–1.5(–1.6) mm _____ **1. C. gronovii**

1. Infrastaminal scales broadly-oblong, apex truncate to slightly bilobed, 1/2(–1/3) as long as the corolla tube; styles 0.3–0.7(–0.9) mm long; capsules 3.5–6.5(–7) × 3–5 (–6) mm; seeds (1.8–)2–2.5(–2.8) × 1.5–1.65 mm _____ **2. C. umbrosa**

Cuscuta gronovii has a wide geographic distribution in North America and is broadly sympatric with *C. umbrosa*. The former is more common in central and northeastern regions (Yuncker 1932), while the latter is primarily a prairie species. *Cuscuta gronovii* usually is distinct from *C. umbrosa* by a greater morphological gap than are the varieties of *C. gronovii* among themselves (see key below).

Within *Cuscuta gronovii*, Yuncker (1965) recognized three varieties: var. *gronovii*, var. *latiflora* Engelm., and var. *calyptrata* Engelm. Variety *latiflora* and variety *gronovii* are broadly sympatric across their geographic range, they show no distinct preferences toward hosts, and morphological intermediates occur. Var. *calyptrata* is more narrowly restricted in range (Texas and Louisiana) but is sympatric with the widespread var. *gronovii*. Continued recognition of sympatric varieties within *Cuscuta gronovii* is unusual. It reflects the observations that (1) a close morphological similarity exists among the varieties, (2) each of the varieties usually is morphologically distinct although intermediates may be relatively common, and (3) each of the non-typical varieties shows features suggesting that it might be more closely related to species of the *Cuscuta cephalanthi-rostrata* group or at least that genetic interchange among taxa of this broader group may have influenced the variation patterns within *C. gronovii*. We consider it premature to discard the varieties as formally recognized taxonomic entities until relationships involving all these taxa are clarified.

1. Cuscuta gronovii Willd. ex Roem. & Schult., Syst. Veg. 6:205. 1820 **(Fig. 1 a, c, f)**. *Epithymum gronovii* (Willd. ex Roem. & Schult.) Nieuwl. & Lunell, Amer. Midl. Naturalist 4:511. 1916. TYPE (see Yuncker 1943): North America, unspecified locality, *Willdenow 3160-10* (B, a photo seen).

Stems medium to coarse, yellow to orange. **Inflorescence** of pedicellate (1–4.5 mm) flowers in loose or dense, paniculate cymose clusters, sometimes endogenously formed; each flower with one ovate to broadly triangular bract at the pedicel base, and sometimes 1–2(–4) bracteoles on the pedicels. **Flowers** 5-merous (sometimes 3- or 4-merous), 2–4(–4.7) mm long, not papillose, white-cream, with a few to many isolated, round to ovoid translucent laticifers in the calyx, corolla, and ovary. **Calyx** cupulate, campanulate to narrow-campanulate, reaching to ca. the middle of the corolla tube or the corolla sinuses, divided ca. 1/2–2/3

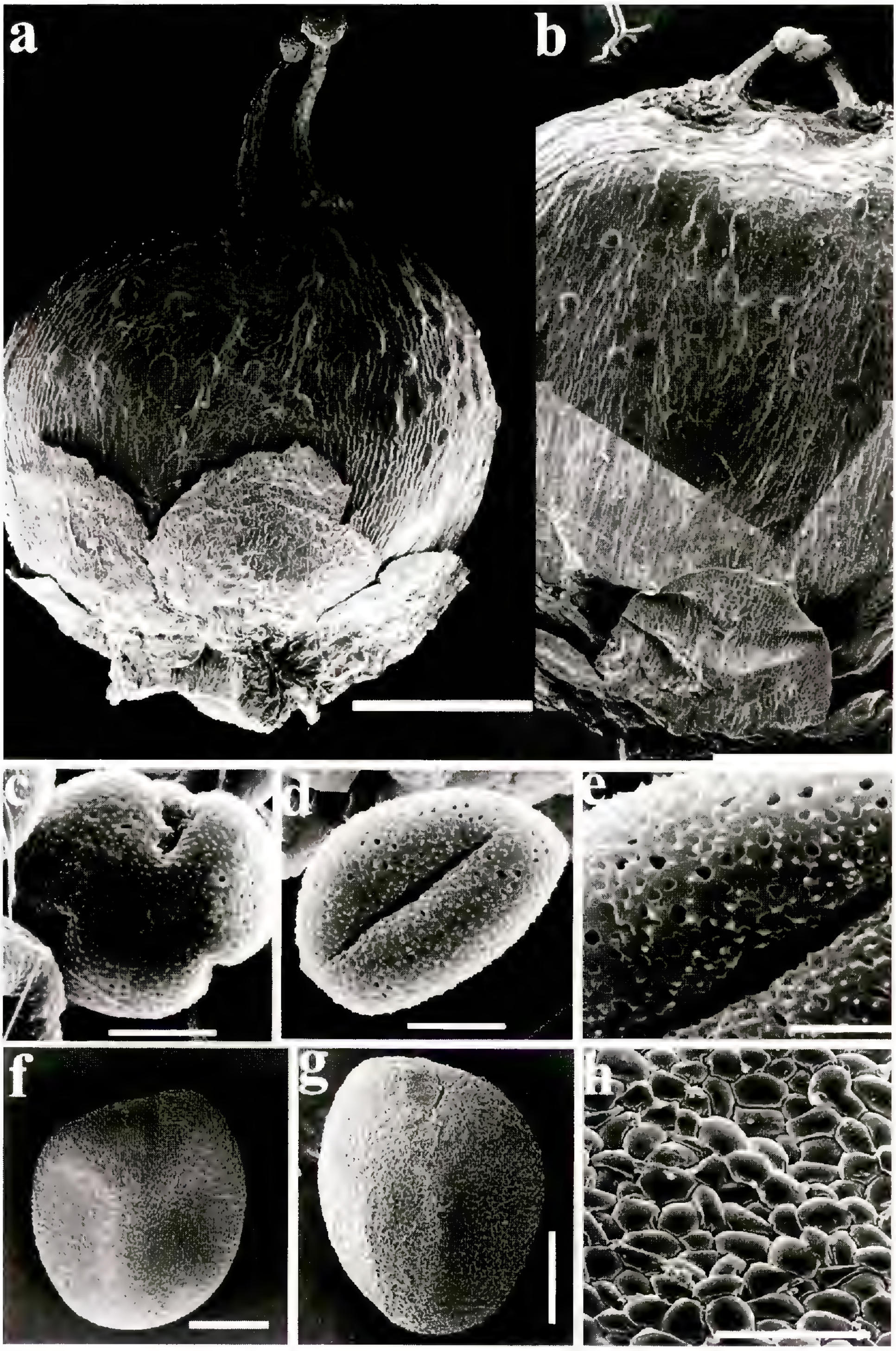


Fig. 1. **a–b.** Capsules with calyx at the base: **a.** *Cuscuta gronovii* var. *gronovii*; **b.** *Cuscuta umbrosa* (assembled from two pictures) (scale bar = 1 mm); **c–e.** Morphology of pollen. **c.** *Cuscuta gronovii* (scale bar = 7.5 μm); **d–e.** *Cuscuta umbrosa* (scale bar = 8.5 and 3 μm, respectively); **f–h.** Morphology of seeds: **f.** *C. gronovii*; **g.** *C. umbrosa* (scale bar = 0.6 mm); **h.** Hydrated seed coat of *C. umbrosa* (scale bar = 120 μm).

the calyx length, lobes ovate to suborbicular or oblong, apex rounded or obtuse, more or less basally overlapping, margins entire to serrulate; **corolla** tube campanulate, broadly- or narrow campanulate (1–)1.5–2.5(–3) mm long, lobes mostly ovate, rounded-obtuse, commonly 1/3 the tube corolla tube, sometimes 1/2 to equaling the corolla tube, spreading or reflexed; epicuticular wax absent or reduced to a few reticulated rodlets; **stamens** exserted, anthers on filaments equaling or longer than anthers; **pollen** 3(–4)-zonocolpate, (18–)19–24(–27) µm long, rounded or truncated at poles, polymorphic in the same anther or flower, from spheroidal to subprolate (the former shape more frequent); tectum imperfortatum with a few puncta, rarely tectum perforatum with puncta 0.3–0.5 µm in diameter; sexine scabrate usually with isolated granules; **infrastaminal scales** oblong or broadly-oblong, rounded or truncate and bifid, deeply fringed distally, shorter than the corolla tube or reaching the filament bases; **styles** distinct, slender, thickened at the base or occasionally slightly subulate, (0.6–)1.2–2.2 mm long; stigmas capitate, globose. **Capsules** globose, ovoid to globose-conic or subobpyriform, thickened at the top, interstylar opening relatively small, sometimes with a short and broad but discernible neck, 2.5–4.5(–5.2) × 2–4(–5) mm, indehiscent or irregularly dehiscent, surrounded or capped by the withered corolla. **Seeds** 2–4 per capsule, 1.35–1.7(–2.4) × 1.2–1.5(–1.6), dorsoventrally compressed to obscurely angled, subrotund to broadly-ovate; hilum subterminal, subrotund, 0.33–0.39 × 0.30–0.33 mm, vascular scar of funiculum linear, 0.20–0.25 mm long, vertical to slightly oblique. Surface of seed epidermis variable: alveolate when dry and papillate when hydrated (cells 20–50 µm in diameter), or cells more or less polygonal and puzzle-like, with epicuticular wax organized as reticulated rodlets. $2n = 60$ (Fogelberg 1938).

KEY TO VARIETIES OF *CUSCUTA GRONOVII*

1. Calyx tube about equaling corolla tube; calyx lobes oblong to ovate, barely overlapping, corolla tube 1–1.5 mm long, broadly campanulate, corolla lobes ca. 1/2 to equaling corolla tube _____ **b. C. gronovii** var. **latiflora**
1. Calyx ca. 1/2 of corolla tube, calyx lobes ovate to suborbicular, overlapping; corolla tube 1.5–2.5 (–3) mm long, campanulate to narrow-campanulate; corolla lobes 1/3(–1/4) of the corolla tube.
   2. Corolla tube narrow-campanulate, 2–2.5 (–3) mm long, withered corolla capping capsule _____ **c. C. gronovii** var. **calyptrata**
   2. Corolla tube campanulate, 1.5–2.5 mm long, withered corolla surrounding the capsule base before falling _____ **a. C. gronovii** var. **gronovii**

a. Cuscuta gronovii var. **gronovii.** *Cuscuta vulgivaga* Engelm., Amer. J. Sci. Arts 43:338. 1842. *Cuscuta gronovii* Willd. ex Roem. & Schult. var. *vulgivaga* (Engelm.) Engelm., Trans. Acad. Sci. St. Louis 1:508. 1859. Engelmann (1842) described three varieties within the species and cited specimens for each of the three (as below), but he did not specify which variety was typical for the species nor did he cite any specimens pertinent to the typical expression of the species, exclusive of varieties. In 1859, he noted for *C. gronovii* var. *vulgivaga* that "It is Willdenow's original *C. gronovii*, in his Hb. nro. 3160" (thus equating var. *vulgivaga* with var. *gronovii*).

Cuscuta vulgivaga Engelm. var. [_] *laxiflora* Engelm., Amer. J. Sci. Arts 43:338. 1842. LECTOTYPE (designated here): U.S.A. ALABAMA: [Oct] 1824, *Buckley s.n.* (MO). Engelmann cited three (or four?) collections: "Western New York on *Decodon*, Dr. A. Gray; Missouri on *Cephalanthus* and *Amphicarpaea*, and Georgia, on ____? [sic], J. Carey; Alabama, on *Salix* and *Aster*, S.B. Buckley." The lectotype sheet has a branch of *Salix nigra* and one of *Symphyotrichum* sp., each hosting *Cuscuta*.

Cuscuta vulgivaga Engelm. var. [_] *glomerata* Engelm., Amer. J. Sci. Arts 43:338. 1842. LECTOTYPE (designated here): U.S.A. VERMONT: On *Leersia*, [no date], *John Carey s.n.* (MO). Engelmann noted that "my specimens are from Vermont on *Leersia*, and New Hampshire, on *Solidago*, both from Mr. J. Carey." The lectotype specimen has a small branch of the host with *Cuscuta* and a packet with dissected flowers. Mounted on the same sheet is a fragment packet with a Carey specimen of *Cuscuta* "on Solidago" from New Hampshire. It appears likely that both specimens are fragments of the original collections.

Cuscuta vulgivaga Engelm. var. [ ] *tetramera* Engelm., Amer. J. Sci. Arts 43:338. 1842. TYPE: U.S.A: Engelmann noted only "Connecticut, on *Urtica*, J. Carey" (HOLOTYPE: MO, presumably, not located).

Distribution and ecology.—The most common and widespread dodder in North America (Engelmann 1859; Yuncker 1965). **CANADA:** Alberta, British Columbia, Manitoba (only a few collections), Ontario, New Brunswick, Nova Scotia, Prince Edward Island, Québec, Saskatchewan (only a few collections). **U.S.A.:** Alabama, Arkansas, Arizona, Colorado, Connecticut, District of Columbia, Florida, Georgia, Iowa, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska., New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin, Wyoming. West Indies (Yuncker 1965) and Europe along water courses (Feinbrun 1972). Growing in a wide variety of climates but apparently preferring shaded and/or wet environments, sometimes occurring as a weed, e.g., in cranberries and grapevine (Parker & Riches 1993). Flowering Jun–Nov. **Hosts:** numerous species from hundreds of genera of herbaceous and wood plants in various families, including Acanthaceae, Anacardiaceae, Apiaceae, Asteraceae, Bignoniaceae, Brassicaceae, Caprifoliaceae, Commelinaceae, Convolvulaceae, Cornaceae, Balsaminaceae, Betulaceae, Euphorbiaceae, Fabaceae, Lamiaceae, Polygonaceae, Primulaceae, Rosaceae, Rubiaceae, Solanaceae, Urticaceae, Verbenaceae, Vitaceae, and others (see also Gaertner 1950). Conservation status: G5 (common) (the same assessment in NatureServe 2005).

b. Cuscuta gronovii var. **latiflora** Engelm., Trans. Acad. Sci. St. Louis 1:508. 1859.

LECTOTYPE (): U.S.A. MISSOURI. Margin of lakes and swamps, in the "American Bottom" opposite Saint Louis, on *Saururus*, Sep 1841, *Geyer s.n.* (MO, designated by Yuncker 1921). Engelmann cited "*C. saururi*, Engelm.!" in synonymy of *Cuscuta gronovii* var. *latiflora*.

Cuscuta saururi Engelm., Amer. J. Sci. Arts 43:339. 1842. *Cuscuta gronovii* Willd. ex Roem. & Schult. var. *saururi* (Engelm.) MacMill., Metasp. Minnesota Valley 430. 1892. LECTOTYPE (Yuncker 1932): U.S.A. MISSOURI: margin of lakes and swamps, in the "American Bottom" opposite Saint

Louis, on *Saururus*, Sep 1841, *Geyer s.n.* (MO). Engelmann also cited "Alabama, Dr. A. Prout; Texas, on *Boehmeria*, *Polygonum*, &c., F. Lindheimer."

Variety *latiflora* is variable and intermediates with var. *gronovii* are relatively common. In seemingly intermediate specimens, on a single plant flowers can be found with the calyx about equaling the corolla tube or somewhat shorter. Apparently, the corolla tube may grow to some extent after fertilization occurs, thus modifying the ratio between calyx length and corolla tube. In var. *gronovii* all the flowers have the calyx about half the corolla tube length. The size of flowers and capsules in var. *latiflora* is similar to *C. cephalanthi*, but the latter differs in its 4-merous flowers and capsules capped by the withered corollas.

Forms of var. *latiflora* with corolla lobes as long as the corolla tube are comparable in floral morphology to *Cuscuta obtusiflora* var. *glandulosa*, which differs mostly in its depressed-globose capsules with large intersylar apertures. Engelmann (1842) also pointed out that var. *latiflora* bears some affinities with *C. polygonorum*, which is closely similar to *C. obtusiflora*.

Distribution and ecology.—The same distribution and hosts as var. *gronovii* but less common. Flowering Sep–Nov.

Conservation status.—G5 (common) (the same assessment in NatureServe 2005).

c. Cuscuta gronovii var. **calyptrata** Engelm., Trans. Acad. Sci. St. Louis 1:508. 1859.

Cuscuta calyptrata (Engelm.) Small, Fl. S.E. U.S. 969. 1903. LECTOTYPE (Yuncker 1921): U.S.A. Western Louisiana, [no date], *J. Gregg s.n.* (MO). Engelmann also cited "Texas, Lindheimer!"

The only differences between var. *calyptrata* and var. *gronovii* apparently are in corolla size and the way the corolla is shed. In var. *calyptrata*, as the capsule expands, the corolla breaks transversely more or less regularly from the base and a permanently narrowed portion of the tube holds the proximal portion of the corolla (including the styles and remnants of the stamens) coherent as it is lifted atop the capsule. In var. *gronovii*, the corolla breaks irregularly, transversely and longitudinally, as the capsule expands and it remains at the capsule base. In the few plants studied that might be intermediate, the corolla tube is not apically narrowed and breaks irregularly but is lifted at the top of the capsule at least in some flowers. Variety *calyptrata* is the most narrowly distributed entity of the *C. gronovii* complex and perhaps the most sharply defined. However, var. *calyptrata* is very similar to *C. cephalanthi* in the unique way corolla caps the mature capsule, but the latter differs in commonly 4-merous flowers, narrower infrastaminal scales, and depressed-globose capsules. The relationships between these three taxa need further study.

Distribution and ecology.—**U.S.A.:** Louisiana, Texas. Flowering Aug–Oct.

Hosts: woody and herbaceous species.

Conservation status.—T1T2 (critically imperiled to imperiled) (T2, NatureServe 2005).

2. Cuscuta umbrosa Beyr. ex Hook., Fl. Bor. Amer. 2:78. 1840. **(Fig. 1 b, d, g, h).**

Grammica umbrosa (Beyr. ex Hook.) W.A. Weber, Southwest. Naturalist 18:319. 1973. LECTOTYPE (designated here): "Northwestern America," *Douglas s.n.* (K). Among three collections, Hooker cited "N.W. Coast of America, Douglas." The interpretation of *C. umbrosa* has been intertwined with that of *C. gronovii* var. *curta* (below), apparently obscuring an unequivocal lectotypification of the earlier name from Hooker's publication. Engelmann (1859) placed "*C. umbrosa* Hook. l.c. in part" in synonymy of *C. umbrosa* var. *curta*, and he cited "Northwestern America, Douglas! Fremont!" Yuncker (1965) treated *Cuscuta gronovii* var. *curta* as a synonym of *C. umbrosa* but noted only that the type locality of *C. umbrosa* was "Northwestern America."

Cuscuta gronovii Willd. ex Roem. & Schult. var. *curta* Engelm., Trans. Acad. Sci. St. Louis 1:508. 1859. *Cuscuta curta* (Engelm.) Rydb., Bull. Torrey Bot. Club 40:466. 1913. LECTOTYPE (Yuncker 1921). "Northwest America (Fremont's 3rd Exped 79), the type, in the Engelmann Herb. (MO). For *C. curta* (with *C. umbrosa* as a synonym), Yuncker (1932) later cited "Northwestern America, (*Douglas*, a specimen in the Kew Herbarium)" as the "type."

Cuscuta megalocarpa Rydb., Bull. Torrey Bot. Club 28:501. 1901. LECTOTYPE (formally designated here, Reveal in herb. 1977): U.S.A. COLORADO: Cucharas Creek, near La Veta, 7000 ft, 15 Sep 1900, *Vreeland 670* (NY). Rydberg also cited *Tweedy 2278*, a collection from Sheridan Co., Wyoming.

Stems medium to coarse, yellow to orange. **Inflorescence** of pedicellate (1–7 mm) flowers commonly in dense, paniculate cymose clusters; each flower with one ovate to broadly triangular bract at the pedicel base. **Flowers** 5-merous (sometimes 4-merous), 2–3.5(–4.4) mm long , not papillose, white-cream, with a few to many isolated, round to ovoid translucent laticifers in the calyx, corolla and ovary. **Calyx** campanulate reaching to ca. the middle of the corolla tube, divided ca. 1/2–2/3 the calyx length, lobes ovate, apex rounded or obtuse, basally overlapping, margins entire to serrulate; **corolla** tube campanulate, 1.7–2.3(–2.7) mm, lobes mostly ovate to broadly-triangular ovate, rounded-obtuse, 1/3–1/4 the tube corolla tube, spreading or reflexed; epicuticular wax absent or reduced to a few reticulated rodlets; **stamens** exserted, anthers on filaments equaling or longer than anthers; **pollen** 3(–4)-zonocolpate, (18–)20–25(–28) µm long, rounded or truncated at poles, polymorph in the same anther or flower, from spheroidal to subprolate (the former shape more frequent); usually tectum perforatum to almost microreticulate, puncta 0.4–0.7 µm in diameter, rarely tectum imperforatum; sexine scabrate with isolated granules; **infrastaminal scales** infrastaminal scales broadly-oblong, and apically truncate to slightly bilobed, fringed, 1/2(–1/3) as long as the tube; **styles** distinct, slender, thickened at the base 0.3–0.7(–0.9) mm long; stigmas capitate, globose. **Capsules** subglobose, ovoid to globose-conic or subobpyriform, thickened at the top, interstylar oppening relatively small, sometimes with a short and broad but discernible neck, 3.5–6.5(–7) × 3–5(–6) mm, indehiscent or irregularly dehiscent. **Seeds** 3–4 per capsule, (1.8–)2–2.5(–2.8) × 1.5–1.65 mm, dorsoventrally compressed to obscurely angled, broadly-elliptic to obovate; hilum subrotund, 0.40–0.60 × 0.39–0.46 mm, vascular scar of funiculum linear, 0.20–0.25 mm long,

vertical to slightly oblique. Surface of seed epidermis alveolate when dry and papillate, with cells 20–50 μm in diameter.

Cuscuta umbrosa is similar in some aspects of flower, fruit, and seed morphology to *C. rostrata*. Both have infrastaminal scales shorter than the corolla tube and large capsules and seeds. *Cuscuta rostrata* is recognizable by the narrower infrastaminal scales and especially by the prominently beaked ovary and capsule. *Cuscuta umbrosa*, however, sometimes produces capsules with a short and broad neck, which may indicate homology with the beaked capsules of *C. rostrata*. **2*n*** = ?

Distribution and ecology.—**CANADA:** Alberta., Manitoba, NW Ontario (only one collection), Saskatchewan. **U.S.A.:** Colorado, Kansas, Minnesota, Montana, Nebraska, New Mexico, New York (as reported by Mitchell and Tucker 1997; possibly a waif), North Dakota, Oklahoma, South Dakota, Utah, Wyoming. Flowering Jul–Oct. Growing in shaded and/or wet environments. **Hosts:** species of *Salix*, *Ampelopsis*, *Symphoricarpos*, *Clematis*, *Epilobium*, *Convolvulus*, *Scutellaria*, *Linum*, and other genera.

Conservation status.—G4G5 (apparently secure to secure) (G5, NatureServe 2005).

APPENDIX 1.
VOUCHERS FOR THE SEM STUDY

1a. Cuscuta gronovii var. **gronovii** (16 collections examined). **CANADA. ONTARIO. Leeds Co.:** Rear of Leeds Twp., 1 km N of Oak Leaf, 6 km SE of Delta, 44 35′20″N 76 02′55″N, 3 Sep 1990, *Catling 5111* (DAO). **NOVA SCOTIA. Lunenburg Co.:** Wentzell Lake, 17 Aug 1921, *Fernald & Long 24402* (NY). **U.S.A. ALABAMA. Montgomery Co.:** Alabama River Bottoms, 4 mi N of Montgomery, 31 Oct 1943, *Kpeooer et al. s.n.* (NY). **ARKANSAS. Hot Springs Co.:** Magnet Cove, 470 ft, 2 Oct 1938, *Hale 2062* (NY). **FLORIDA. Taylor Co.:** vicinity of Adams Beach, 16 Oct 1961, *Godfrey & Honk 61565* (NY). **GEORGIA. Fulton Co.:** Atlanta, 1164 Clifton Rd., 1 Oct 1956, *Burbanck s.n.* (NY). **INDIANA. Franklin Co.:** bank of river 4 mi S of Laurel, 12 Oct 1924, *Deam 41026* (NY). **MAINE. Knox Co.:** seashore Martinsville, 14 Aug 1952, *Friesner s.n.* (NY). **MASSACHUSETTS. Barnstable Co.:** 26 Aug 1928, *Fernald et al., Exiccatae Grayane 480* (NY). **MICHIGAN. Kent Co.:** 7 mi N of Lowell, 28 Aug 1931, *Yuncker & Welch 3792* (NY). **MISSISSIPPI. Noxubee Co.:** 3 mi of Macon, 22 Oct 1960, *McDaniel 2276* (NY). **MISSOURI. Jefferson Co.:** 6.5 mi W of DeSoto, 38 07′30″N 90 40′30″ , 25 Aug 1991, *Raven & Raven 27930* (NY). **Saint Louis Co.:** near Saint Louis, 1878, *Eggert s.n.* (NY). **NEW JERSEY. Middlesex Co.:** opposite New Brunswick, Oct 1918, *Mackenzie s.n.* (NY). **OHIO. Ottawa Co.:** Turtle Creek, Ottawa National Wildlife Refuge, 570 ft, 22 Aug 1996, *Hill 28542* (NY). **PENNSYLVANIA. York Co.:** near McCall's Ferry, 9 Sep 1893, *Heller & Halbach 1357* (NY). **WISCONSIN. Waushara Co.:** 2.5 mi SSW of Borth, 15 Aug 1984, *Bewick 100* (NY).

1b. Cuscuta gronovii var. **latiflora** (12 collections examined). **U.S.A. INDIANA. Daviess Co.:** 1.5 mi SE of Newberry, 21 Sep 1932, *Deam 53259* (NY). **Pasey Co.:** 12 mi SW of Mt. Vernon, 20 Aug 1922, *Deam 37712* (NY). **Sullivan Co.:** along Busseron Creek, 2 mi E of Sullivan, 3 Oct 1931, *Deam 51395* (NY). **IOWA. Wapello Co.:** Cliffland, NW1/4 Sec. 11, T-71N, R-13W, 30 Sep 1954, *Davidson 4051* (NY). **MARYLAND.** (no county given): at mouth of Little Gunpowder River, 2 Sep 1902, *Shull 289* (NY). **MICHIGAN. Kalamazoo Co.:** Portage Twp., 20 Jul 1936, *Hanes s.n.* (NY). **NEW JERSEY. Mercer Co.:** Duck Island, below Trenton, 21 Aug 1921, *Mackenzie s.n.* (NY). **NEW YORK. Nassau Co.:** Long

Island, Oyster Bay, 11 Sep 1926, *Ferguson 6091* (NY). **Suffolk Co.:** Long Island, Water Mill, 10 Aug 1925, *Ferguson 4293* (NY). **Wayne Co.:** Lake Ontario, Fairbanks Point, Williamson Twp., 246 ft, 10 Aug 1939, *Hinkey 4484* (NY). **TEXAS. Wood Co.:** Lake Ellis, 3 Sep 1942, *Lundell 11750* (NY). **VIRGINIA. Princess Anne Co.:** along North Landing River, near Creed's, 9 Sep 1935, *Fernald et al. 5011* (NY).

1c. Cuscuta gronovii var. calyptrata (1 collection examined). **U.S.A. TEXAS. Rockwall Co.:** 3.25 mi NW of Rockwall, 22 Oct 1946, *Cory 52529* (SMU).

2. Cuscuta umbrosa (14 collections examined). **CANADA. ALBERTA:** Lethbridge, 30 Aug 1971, *Allen 150* (DAO). **MANITOBA:** Aweme (?), 9 Aug (no year), *Criddle s.n.* (DAO); Delta, S13-T14-R7, 20 Aug 1953, *Löve & Löve 6199* (DAO); Delta Marsh, University Field Station, 50°11'N 98° 24'W, 9 Aug 1984, *Szumigalski 18* (DAO); Otterburne, 13 Aug 1954, *Bernard 497* (DAO); Winnipeg, Mulvey Avenue, Sep 1975, *Fields s.n.* (DAO). **SASKATCHEWAN:** Carnduff, 20 Aug 1948, *Budd & Lodge 1197* (DAO); 10 mi S of- and 0.5–1 mi E of Gainsborough, Hutler River Valley, NE1/4 Sec. 9 T1 R30 W1, 29 Jul 1988, *Harms 39594* (DAO). **U.S.A. COLORADO. Teller Co. (?).:** Manitou (Experimental Forest?), 31 Aug 1892, *Mulford s.n.* (NY). **MINNESOTA. Carlton Co.:** 3 mi SW of Fond du Lac, 22 Aug 1945, *Moore & Huff 18199* (DAO). **NORTH DAKOTA. Cass Co.:** Fargo, 9 Sep 1950, *Stevens 1228* (DAO). **SOUTH DAKOTA. Potter Co.:** Forest City, Sep 1892, *Griffiths & Glosser s.n.* (NY). **UTAH. Salt Lake Co.:** City Creek Canyon, 8000 ft, 10 Aug 1883, *Leonard 250* (NY).

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Book Review

Vinaya Ghate, Hema Sane, and S.S. Ranade (compilers and editors). 2004. **Focus on Sacred Groves & Ethnobotany.** (ISBN 81-8540502-6, hbk.). Proceedings of the National Seminar on Ethnobotany & Sacred Groves: "Role in Conservation Strategy for India." [Edited by Dr. Vinaya Ghate] Prism Publications, Chembur, Mumbai (India). Distributor: Timely Management Consl.Ser.Put.Ltd., 14/4 Shivpuri, Sion Trombay Road, Chembur, Mumbai 400 071, INDIA. (**Orders:** Ph: 91-22-2522 7616 / 2529 5725 Fax: 91-22-2524 2484, ajitn@vsnl.com). Rs.900 (US $50), 253 pp., photographs, 7.5" × 10" (19 × 25 cm).

Sacred groves are relatively small, some no more than a stand of trees, few larger than an acre of mixed climax vegetation. Within them the locals worship the deities to whom the groves are dedicated and also hold festivities of dance and song in their honor. Because collecting live or fallen plant materials or the cutting of them is taboo, the groves may be the last hold out of plants that could be threatened with extinction as the surrounding forests are cleared for human purposes. The groves are therefore important for conservation.

Dr. V.D. Vaktar, who taught at the University of Pune, was a leader in the study of ethnobotany of western India. The conference and this book commemorate his work. The first part of the book contains articles that Dr. Vaktar (and co-authors) published between 1973 and 1998. Part 2 comprises papers presented at the seminar: studies of botany of various locales, plants important in religious observances, medicinal plants and their applications. The need for conservation of plants in the sacred groves and elsewhere is obvious in all the papers—*Joann Karges (retired TCU Library), Botanical Research Institute of Texas, Fort Worth, TX 76102-4060, U.S.A.*

TAXONOMY OF THE *CUSCUTA INDECORA* (CONVOLVULACEAE) COMPLEX IN NORTH AMERICA

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ABSTRACT

The *Cuscuta indecora* complex (*Cuscuta* subsect. *Indecorae*) in North America is characterized by fleshy, papillose flowers, corolla lobes with inflexed tips, and capsules with a thickened stylopodium. It includes *C. indecora*, *C. coryli*, *C. warneri*, and *C. jepsonii*. Recent taxonomists have proposed to treat the latter three taxa at varietal rank within *C. indecora* or as synonyms of it. We maintain *C. warneri* and *C. jepsonii* at specific rank because of their distinctive morphology, even though the latter is known only from the type collection and the former from a very limited number of specimens. *Cuscuta indecora* includes var. *indecora*, var. *longisepala*, and **C. indecora** var. **attenuata** (Waterfall) Costea, comb. et stat. nov. *Cuscuta indecora* vars. *bifida* and *neuropetala* are treated as synonyms of *C. indecora* var. *indecora*. *Cuscuta warneri* and *C. coryli* are reported as new floristic records from New Mexico and Québec, respectively.

RESUMEN

El complejo *Cuscuta indecora* (*Cuscuta* subsect. Indecorae) en América del Norte está caracterizado por flores papilosas y suculentas, lóbulos de la corola con puntas inflexionadas, y cápsulas con un estilopodio engrosado. El complejo incluye *C. indecora*, *C. coryli*, *C. warneri*, y *C. jepsonii*. Recientemente algunos taxónomos han propuesto tratar las últimas tres variedades dentro de la categoría *C. indecora* o como un sinónimo del mismo. Mantenemos que *C. warneri* y *C. jepsonii* están en una categoría especial por su morfología distinta, a pesar de que la última se conoce sólo por la colección del tipo, y la primera es conocida mediante un número de especimenes muy limitado. *Cuscuta indecora* incluye var. *indecora*, var. *longisepala*, y **C. indecora** var. **attenuata** (Waterfall) Costea, comb. et stat. nov. *Cuscuta indecora* vars. *bifida* y *neuropetala* son tratadas cómo sinónimos de *C. indecora* var. *indecora*. *Cuscuta warneri* y *C. coryli* figuran como nuevas citas florísticas de Nuevo México y Quebec, respectivamente.

Cuscuta subsect. *Indecorae* Yuncker is characterized by fleshy, papillose flowers, corolla lobes with inflexed tips, and capsules with a thickened stylopodium

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(Yuncker 1932, 1965). In Yuncker's view, it included three North American species (*C. indecora* Choisy, *C. coryli* Engelm., and *C. warneri* Yuncker) and one from South America (*C. stenolepis* Engelm.). A fifth species, *C. attenuata* Waterfall, was added to subsect. *Indecorae* by Prather and Tyrl (1995), although Waterfall (1971) had suggested that *C. attenuata* resembled *C. compacta* Juss. of subsect. *Lepidanche* Engelm. *Cuscuta attenuata* is closely similar to *C. indecora*, but Prather and Tyrl (1995) maintained both at specific rank, emphasizing their apparent reproductive isolation. *Cuscuta warneri* was treated by Beliz in her Ph.D. thesis (1986) as a variety of *C. indecora*; this unpublished combination has been included in some recent North American overviews (e.g., Kartesz 1999). *Cuscuta jepsonii* Yuncker, which was initially treated in subsect. *Californicae* Yuncker (Yuncker 1932), has been recently considered conspecific with *C. indecora* (Beliz 1993, 2002). The taxonomic status and relationships of these taxa are reevaluated here, based on morphology and micromorphology of flowers, capsules, seeds, and pollen.

METHODS

Descriptions of morphology are based on samples from specimens from NY, which includes Yuncker's herbarium (Appendix 1). Measurements and pictures were taken with a scanning electron microscope Hitachi S-570 at 15 KV. Samples were coated with 30 nm gold using an Emitech K 550 sputter coater. Terminology regarding the micromorphology of flowers, seeds and capsules, and pollen were described in detail in the first paper published in this issue (Costea et al. 2006). Conservation status was assessed using NatureServe (2005) ranks and criteria.

TAXONOMY

Cuscuta indecora and C. coryli.—*Cuscuta indecora* is a highly variable and common species both in North America and South America (Engelmann 1859; Yuncker 1921, 1932, 1965; Beliz 1986; Prather & Tyrl 1995). *Cuscuta coryli* is less variable and is sympatric with *C. indecora* over a significant geographic area (see below). Yuncker (1932) mentioned that *C. coryli* "is closely related to *C. indecora*, but is distinguished by its often 4-parted flowers which are commonly smaller (ca. 2 mm long), rudimentary scales and shape of fruit." We find that flowers of *C. coryli* may be both 4-merous and 5-merous on the same specimen, and sometimes even 3-merous. Engelmann (1843) noted "flowers frequently 5-parted" for *C. coryli*, but he later (1859) modified this observation to flowers "mostly 4-parted." Although the type and many collections of *C. coryli* apparently have more 4-merous than 5-merous flowers, 5-merous flowers predominate in some specimens. Ranges of variation in floral size in *C. indecora* and *C. coryli* are closely similar. *Cuscuta indecora* has small flowers, 2.1–2.7 mm long,

with the corolla tube 0.9–1.5 mm long; flowers of *C. coryli* are 1.7–2.6(–3) mm long, with the corolla tube (0.7–)1–1.4 mm long.

Such observations perhaps led Beliz (1987–1988, in herb. NY, GH) to consider *Cuscuta coryli* conspecific with *C. indecora*. Although they are clearly related and sometimes overlapping in several character states, the two taxa can be usually distinguished using a combination of characters (see key and descriptions below) and their recognition as separate species is appropriate.

Description of infrastaminal scales in these two species has been confusing. For example, in *Cuscuta coryli*, Engelmann was consistent, describing the infrastaminal scales as "appressed, bifid, consisting of a few teeth ... one or two teeth on each side of the filament (1942) ... or lobes laterally adhering to the lower (attached) part of the filament" (1859). Yuncker (1921, 1932) added "scales rudimentary, bifid, toothed, ordinarily reduced to toothed wings on either side of filament attachment." Figure 42e (1921) depicted one bifid infrastaminal scale with 1 or 2 fimbria on the each side of the staminal filament, while in Fig. 39 (1932), these lateral fimbria are replaced by dentate lobes (wings). In his 1965 treatment, Yuncker removed the term "bifid" from the description of infrastaminal scales of *C. coryli* and applied it to *C. indecora* var. *bifida* Yuncker, which was described as identical in other respects to *C. indecora* var. *indecora*. We find that the infrastaminal scales of var. *bifida* are not truly bifid, but rather the spathulate scales may have 2 or 3(–4) deeper apical incisions, which create 2 or 3(–4) lobes that are further fringed. "Normal" scales may occur in the same flower together with lobed ones. Such plants are regarded here as populational variants of *C. indecora* var. *indecora*. Bifid scales, as pointed out by Engelmann (1842, 1859), are characteristic of *C. coryli*.

The varieties of *C. indecora* and the status of *Cuscuta attenuata*.—Yuncker (1965) treated *Cuscuta indecora* with three varieties (var. *indecora*, var. *bifida*, and var. *longisepala*): as noted below, we tentatively maintain var. *longisepala* but var. *bifida* is not appropriately recognized. *Cuscuta indecora* var. *neuropetala* (Engelm.) Hitchc., distinguished by its relatively larger flowers, has been accepted in recent overviews of the genus (Beliz 1993, 2002; Kartesz 1999). We find that although var. *neuropetala* can be often identified, its connection to var. *indecora* by a series of intermediates makes taxonomic recognition unfeasible.

Prather and Tyrl (1995) observed that *Cuscuta attenuata* is morphologically similar to *C. indecora*. Indeed, Yuncker annotated (in herb. NY) some collections of *C. attenuata* as *C. indecora* var. *longisepala*. The present study substantiates the similarities, which extend to the morphology and micromorphology of perianth, seeds, pollen, and capsules. The geographic range of *C. attenuata* lies completely within that of var. *indecora*, but preliminary evidence suggests that *C. attenuata* may have a narrower host preference. In UPGMA and principal components analyses by Prather and Tyrl, *C. attenuata* is part of a single

cluster with *C. indecora* var. *indecora* and var. *longisepala*; univariate analyses separated these three taxa, although they were broadly overlapping in morphology. Prather and Tyrl (p. 456) concluded that "*C. attenuata* is a distinct species albeit morphologically similar to *C. indecora*. In the absence of reproductive isolation we might treat *C. attenuata* as a variety of *C. indecora*." Experimental crosses by Prather and Tyrl between *C. attenuata* and both varieties of *C. indecora* produced neither fruits nor seeds, while populations of *C. attenuata* were interfertile. Whether var. *indecora* and var. *longisepala* were interfertile was not reported.

For consistency with the degree of morphological difference between other *Cuscuta* species (as we are recognizing them), *C. attenuata* is treated here at varietal rank within *C. indecora*. In view of its apparent reproductive isolation and host specialization, it is a more strongly defined entity than var. *longisepala*, which also is broadly sympatric with var. *indecora*. Var. *longisepala* is tentatively maintained here, until its biology and evolution may be better understood.

Cuscuta warneri.—This species is a strikingly distinct dodder. Each calyx lobe is apically prolonged into a conical spur-like projection (Fig. 4 a,b,d), infrastaminal scales are oblong with truncate and dentate apex, and capsules have a collar-like apex and very short styles (Fig. 4d). The calyx spurs are accrescent, relatively small in flower and reaching maximum size in fruit, when they detach easily (at least on dry material). *Cuscuta warneri* shows strong similarity to *C. indecora* in morphology and micromorphology of perianth, capsules, seeds, and pollen (as also observed by Yuncker 1960). Beliz (1986) wrote that "critical studies, however, indicate that *C. warneri* is probably an abnormal specimen of *C. indecora* ... and until more material is available for studies, *C. warneri* is recognized as a variety of *C. indecora*." Our observations, in contrast, do not indicate that *C. warneri* is teratological. Flowers have all the components and they are fertile, each capsule usually with 2 seeds in which the embryos appear to develop normally. The fact that *C. warneri* is known only from the type locality and a collection from New Mexico (see bellow) indicates that its distribution is localized, but its morphological distinction justifies continuing recognition at specific rank.

The spur-like projections of the perianth of *Cuscuta warneri* have an unknown biological role. Similar morphology also is encountered in other, more distantly related species: *C. runyonii* Yuncker, *C. applanata* Engelm., *C. boldinghii* Urban, and *C. chapalana* Yuncker.

Cuscuta jepsonii.—This species was described and included by Yuncker (1921, 1933) in subsect. *Californicae* because infrastaminal scales are absent or reduced to ridges. Beliz (1986) initially considered it to be a synonym of *C. californica* Hook. & Arn. var. *papillosa* Yuncker, but she later (1993) treated it as a synonym of *C. indecora* var. *indecora*. She did not provide substantiating evidence for these decisions. The species is known only from the UC holotype.

Based on study of this collection, we confirm that *C. jepsonii* may belong to subsect. *Indecorae*, where it represents an extreme case of infrastaminal scale reduction. The 5-merous flowers and papillae morphology are similar to *C. indecora*, from which it differs by very small anthers, 0.2–0.3 mm long, which are more like those of *C. coryli*.

Infrastaminal scales vary to some extent in many *Cuscuta* species. Nevertheless, we know of no instance of complete reduction of infrastaminal scales in a species where scale development is characteristically normal, even if variable. For this reason, and until additional material can be studied, *C. jepsonii* is maintained as a distinct species.

KEY TO THE SPECIES OF *CUSCUTA* SUBSECT. *INDECORAE* IN NORTH AMERICA

1. Infrastaminal scales absent or reduced to ridges _____ **4. C. jepsonii**
1. Infrastaminal scales present.
   2. Calyx lobes with an apical spur-like projection; infrastaminal scales dentate at apex _____ **3. C. warneri**
   2. Calyx lobes without spur-like projections; infrastaminal scales fimbriate.
      3. Flowers commonly 5-merous, 2–5.3 mm long, infrastaminal scales united with the corolla tube for 1/3–1/2 (rarely 3/4) of their length, subspathulate to spathulate, rarely 2–3 lobed, apex rounded rarely truncate, with (6–)20–35(–50) fimbria; capsule yellowish and ± semi-transparent when dried, globose, subglobose to slightly depressed-globose, 0.8–1.5 times wider than long, the suture lines between the 2 carpels not or only slightly depressed _____ **1. C. indecora**
      3. Flowers (3–)4–5-merous, 1.7–2.6(–3) mm long; infrastaminal scales united with the corolla tube for most of their length, oblong, bifid with 1–3 fimbria on each side of filament attachment, rarely ± truncate with 3–6 fimbria; capsule brown and not semi transparent when dried, initially globose, becomes depressed, 1.6–2.4 times wider than long, the suture lines between the 2 carpels depressed, forming a longitudinal groove on the opposed sides of capsule _____ **2. C. coryli**

1. Cuscuta indecora Choisy, Mém. Soc. Phys. Genéve 9:278, t.3, f.5. 1842 (**Fig. 1, Fig. 3a,d,e,g,h**). *Cuscuta decora* Choisy ex Engelm. var. *indecora* (Choisy) Engelm., Trans. Acad. Sci. St. Louis 1:502. 1859. *Grammica indecora* (Choisy) W.A. Weber, Southw. Naturalist 18:319. 1973. *Epithymum indecorum* (Choisy) Nieuwl. & Lunell, Amer. Midl. Naturalist 4:511. 1916. TYPE: MEXICO. [TAMAULIPAS]: "Mexicum ad Matamoros," *Berlandier 2285-865* (HOLOTYPE: G-DC; ISOTYPES: MO, P).

Stems 0.4–0.7 mm thick, yellow to orange. **Inflorescences** loose to dense, paniculate-cymose clusters, sometimes originating endogenously; pedicels 0.5–6 mm long, papillate-hispid to glabrous; bracts one (rarely 0) at the pedicel base, ovate to lanceolate. **Flowers** (4–)5-merous, 2–5.3 mm long fleshy, translucent-white when fresh, of the same color or dark-brownish when dried; epidermal cells arranged in rows, fleshy, with anticlinal walls convex (dome-like), additionally with cylindric-conical papillae 40–80 µm long; when flowers dry up, rows of dehydrated epidermal cells are usually easily discernible; epicuticular wax represented by longitudinally reticulated rodlets; laticifers isolated or in

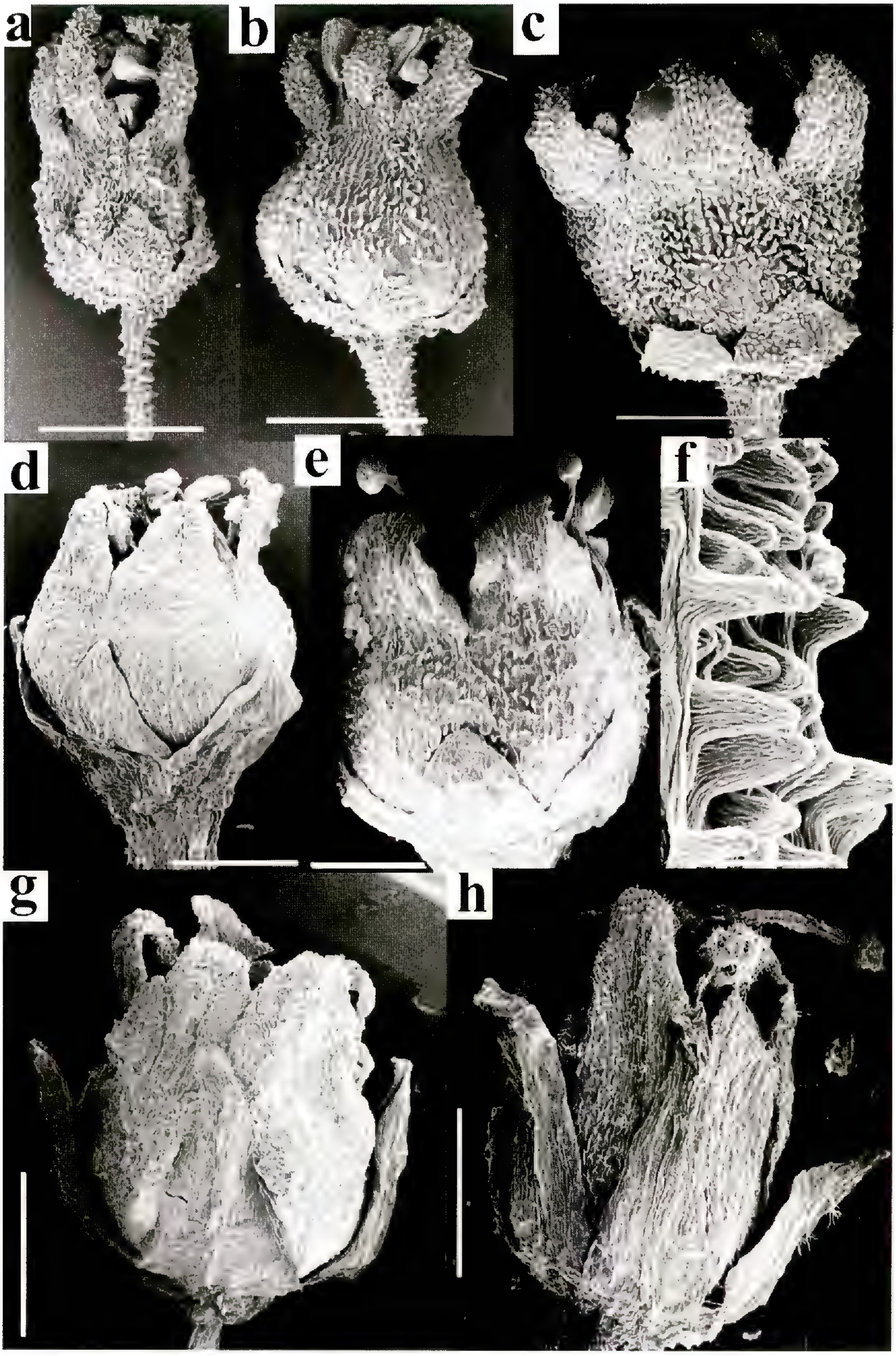


FIG. 1. Floral variation in *C. indecora*: **a**–**e.** var. *indecora* (scale bar = 1 mm); **f.** Papillae on the calyx of var. *indecora* (scale bar 75 μm); **g.** var. *longisepala*; **h.** var. *attenuata* (scale bar = 1 mm).

longitudinal rows, ovoidal to elongated, present in the perianth along the midveins, ovary and capsules often running longitudinally and yellowish-orange colored. **Calyx** cupulate, 1/2 to somewhat longer than the corolla tube, divided 1/2–2/3 of the length, lobes triangular-ovate to lanceolate, acute to attenuate, more or less overlapping at the base. **Corolla** tube campanulate, campanulate-cylindric, subglobose or suburceolate, 1–3.2 mm long, lobes 0.7–1.5 mm long triangular-ovate, acute, ca. 1/3 to equaling corolla length, suberect to erect, apically inflexed. **Stamens** barely exserted or enclosed; anthers elliptic to oblong, (0.5–)0.6–0.9(–1.2) × 0.3–0.5 mm long; filaments equaling or longer than anthers; pollen 3(–4)-zonocolpate, subprolate to prolate, 24–36 µm long, tectum imperforatum or with a few isolate puncta, sexine scabrate with isolated granules. **Infrastaminal scales** reaching the filaments, united with the corolla tube for 1/3–1/2 (rarely 3/4) of their length; subspathulate to spatulate, apex rounded, rarely truncate or 2–3(–4) lobed, with (6–)20–35(–50) fimbria. **Styles** distinct, 1–2.5 mm long, ± unequal, evenly filiform, suberect or weakly divergent; stigmas capitate, globose. **Capsules** yellowish to light-brown and ± semi-transparent when dried (pericarp thin), glabrous, subglobose, globose, to slightly depressed-globose, 0.9–1.5 wider than long, narrowed and thickened around the style bases, indehiscent or irregularly dehiscent, surrounded or capped by the withered corolla; pericarp epidermis smooth. **Seeds** 2–4 per capsule, 1.42–1.86 × 1.25–1.6 mm, shape heterogeneous on the same plant: dorsoventrally compressed to weakly angled, broadly elliptic to transversely oblique, hilum subterminal, rarely almost terminal, broadly elliptic, 0.40–0.45 × 0.32–0.36 mm; vascular scar linear, 0.15–0.18 mm, vertical; seed surface variable: a) epidermis cells more or less polygonal and puzzle-like, b) alveolate when dry and papillose when wet, and c) only some cells are papillose and the rest are ± puzzle-like; size of epidermal cells 20–50 µm in diameter.

KEY TO THE VARIETIES OF *CUSCUTA INDECORA*

1. Calyx lobes ovate triangular, reaching ca. 1/2 of the corolla tube _____ **a. C. indecora** var. **indecora**

1. Calyx lobes lanceolate mostly longer than the corolla tube.
   2. Calyx lobes acute; flowers in loose clusters; parasitic on a wide range of species _____ **b. C. indecora** var. **longisepala**
   2. Calyx lobes attenuate; flowers in dense clusters; parasitic primarily on *Iva annua* _____ **c. C. indecora** var. **attenuata**

a. Cuscuta indecora var. **indecora. (Fig. 1 a,b,c,d,e)**. *Cuscuta neuropetala* Engelm., Amer. J. Sci. Arts 45:75. 1843. *Cuscuta indecora* Choisy var. *neuropetala* (Engelm.) Hitchc., Contr. U.S. Natl. Herb. 3:549. 1896. TYPE: U.S.A. TEXAS. [Harris Co.]: in wet prairies near Houston, on different Compositae, such as *Liatris*, *Solidago*, *Helianthus*, *Rudbeckia*, and on *Myrica cerifera*, Aug 1843, *Lindheimer 124* (HOLOTYPE: MO; ISOTYPES: NY, US).

Cuscuta neuropetala Engelm. var. *littoralis* Engelm., Boston J. Nat. Hist. 5:223. 1845. LECTOTYPE (here designated; Beliz 1986, in herb.): U.S.A. TEXAS. [Galveston Co.]: Galveston, Apr 1843,

Lindheimer s.n. (MO; ISOLECTOTYPE: NY). The protologue noted "Seashore of Galveston Island, on *Lycium carolinianum*, *Borrichia frutescens*, *Iva frutescens*, etc. Flowers in May."

Cuscuta verrucosa Engelm. var. *hispidula* Engelm., Amer. J. Sci. Arts 43:341. 1842. *Cuscuta indecora* var. *hispidula* (Engelm.) Yuncker, Illinois Biol. Monogr. 6:148. 1921. TYPE: U.S.A. TEXAS. [Harris Co.]: "in dry and sterile prairies, west of Houston, on *Euthamia*, *Schrankia*, *Aster*, *Ambrosia*, *Evolvulus*, and other low herbs, flowering in April and May, *F. Lindheimer*" s.n. (HOLOTYPE: MO, presumably). Yuncker (1921) cited *Berlandier 2285-MO* as the type of *C. indecora* var. *hispidula*, but that collection is interpreted here as the holotype of *C. indecora* (var. *indecora*).

Cuscuta hispidula Engelm., Amer. J. Sci. Arts 45:75. 1843. TYPE: U.S.A. TEXAS. [Harris Co.]: Engelmann did not cite a collector but noted "in dry and sterile prairies west of Houston. Flowering in April and May," apparently referring to the same Lindheimer collection typifying *C. verrucosa* var. *hispidula* (above). *Cuscuta hispidula* apparently was not intended by Engelmann to be a new combination based on the earlier *C. verrucosa* Engelm. var. *hispidula*, as he wrote "*Cuscuta hispidula* n. sp." and "Compare the remarks made in Vol. XLIII p. 341, under *C. verrucosa*."

Cuscuta indecora var. *bifida* Yuncker, Illinois Biol. Monogr. 6:149. 1921. LECTOTYPE (designated here): U.S.A. NEVADA. Twin Springs, May-Oct, *Purpus 6343* (UC 124538). Two sheets at UC are marked as "isotype" of var. *bifida*: the other is *Purpus s.n.*, without date (UC 124541).

Distribution and ecology.—**CANADA:** Saskatchewan. **U.S.A.:** Alabama, Arkansas, Arizona, California, Colorado, Connecticut, Florida, Georgia, Idaho, Iowa, Illinois, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, North Carolina, North Dakota, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, Wyoming. **MEXICO; WEST INDIES; SOUTH AMERICA.** It is probably the third most common dodder in North America, after *C. gronovii* and *C. campestris*. It is listed as a "locally" important weed in the U.S.A. and Argentina (Parker & Riches 1993). Flowering Jul–Nov. **Hosts:** wide range of herbaceous and woody species, e.g., *Agalinis*, *Baccharis*, *Borrichia*, *Chenopodium*, *Eupatorium*, *Helianthus*, *Heterotheca*, *Hypericum*, *Ipomoea*, *Iva*, *Kosteletzkya*, *Lepidium*, *Ligustrum*, *Myrica*, *Pluchea*, *Polygonum*, *Rhynchosia*, *Solidago*, *Suaeda*, *Symphyotrichum*, *Tephrosia*, *Vernonia*.

Conservation status.—G5 (common) (NatureServe 2005). ***n*** = 15 (Pinkava et al. 1974); **2*n*** = 30 (Pazy & Plitmann 1995).

b. Cuscuta indecora var. **longisepala** Yuncker, Illinois Biol. Monogr. 6:149, Fig. 44, 97. 1921 **(Fig. 1g).** TYPE: U.S.A. TEXAS. On the Blanco, *Wright s.n.* (HOLOTYPE: MO).

Distribution and ecology.—**U.S.A.:** Texas. **MEXICO; SOUTH AMERICA.** Flowering summer–fall. **Hosts:** herbaceous and woody species. Conservation status: T2T1 (imperiled to critically imperiled) (not yet assessed by NatureServe 2005).

c. Cuscuta indecora var. **attenuata** (Waterfall) Costea, comb. & stat. nov. **(Fig. 1h).** *Cuscuta attenuata* Waterfall, Rhodora 73:575. 1971. TYPE: U.S.A. OKLAHOMA. McCurtain Co.: Waterfall Creek, 8 mi S and 2 mi E of Idabel, *Waterfall 17157* (HOLOTYPE: OKLA; ISOTYPE: GH).

Distribution and ecology.—**U.S.A.:** Kansas, Oklahoma, Texas (Prather & Tyrl 1993).

Conservation status.—imperiled (G2) (Natureserve 2004). Flowering late Aug–Oct. **Hosts:** *Iva annua*, rarely *Symphyotrichum* spp., mudflats, floodplains, and disturbed areas.

Conservation status.—T2T1 (imperiled to critically imperiled) (G2, Natureserve 2005). ***2n*** = 30 (Prather & Tyrl 1993).

2. Cuscuta coryli Engelm., Amer. J. Sci. Arts 43:337. 1842. (**Fig. 2, Fig. 3 b, c, f).**
TYPE: U.S.A. MISSOURI. [St. Louis Co.]: "on *Corylus* near St. Louis," Sep 1841, *Engelmann s.n.* (HOLOTYPE: MO; ISOTYPE: GH). The protologue reads "on *Corylus*, in the barrens west of St. Louis, in August and September."

Cuscuta coryli Engelm. var. *stylosa* Engelm., Amer. J. Sci. 43:337. 1842. TYPE: U.S.A. MISSOURI. [St. Louis Co.]: "on *Solidago*, St. Louis," Sep 1841, *Engelmann s.n.* (HOLOTYPE: MO; ISOTYPES: GH, US). The protologue reads "On *Solidago*, in dry prairies near St. Louis."

Cuscuta inflexa Engelm., Trans. Acad. St. Louis 1:502. 1859 [nom. invalid.]. Apparently a renaming of *Cuscuta coryli*, as the latter was cited immediately and first in synonymy (other names at specific rank also were cited). A number of collections were cited in the protologue.

Stems 0.30–0.50 mm thick, yellow to orange. **Inflorescences** usually dense (sometimes loose), paniculate-cymose clusters, sometimes originating endogenously; pedicels 0.5–3 mm long, glabrous; bracts one at the pedicel base, ovate to lanceolate. **Flowers** 4–5-merous (rarely 3-merous), 1.7–2.6(–3) mm long, fleshy, white when fresh, commonly dark-brownish when dried; epidermal cells fleshy, organized in rows with anticlinal walls convex (dome-like); papillae like those described in *C. indecora* usually absent; when flowers dry up, rows of dehydrated epidermal cells are more or less inconspicuous; epicuticular wax present represented by longitudinally reticulated rodlets; laticifers isolated or in longitudinal rows, ovoidal to elongated, present in the perianth midveins, ovary and capsules. **Calyx** cupulate, equaling or somewhat longer than corolla tube, rarely in some flowers shorter than corolla tube, divided 1/2–2/3 of the length, lobes triangular-ovate, acute, not or only slightly overlapping at the base. **Corolla** tube campanulate to suburceolate, 0.5–1.3(–1.5) mm long, lobes 0.8–1.2(–1.5) mm long, triangular-ovate, acute, ca. 1/3 to equaling corolla length, suberect to erect, apically inflexed. **Stamens** barely exserted or enclosed; anthers (0.2–)0.3–0.45 × 0.19–0.25 mm long; filaments equaling or longer than anthers; pollen as in *C. indecora*. **Infrastaminal scales** ca. reaching the filaments, united with the corolla tube for most of their length, oblong, bifid, with short dentate wings or 1–3 fimbria on each side of filament attachment, rarely truncate with 3–6 fimbria. **Styles** distinct, 0.7–1.5 mm long, ± unequal, evenly filiform, strongly divergent in capsule; stigmas capitate, globose. **Capsules** dark-brown and not semi-transparent when dried (pericarp thick), glabrous, initially globose later become evidently depressed, 1.6–2.4 times wider than long; the former suture lines between the 2 carpels forming a longitudinal groove on opposed sides of capsule; depressed and thickened around the style bases, indehiscent or irregularly dehiscent, surrounded or capped by the withered corolla; pericarp epidermis with

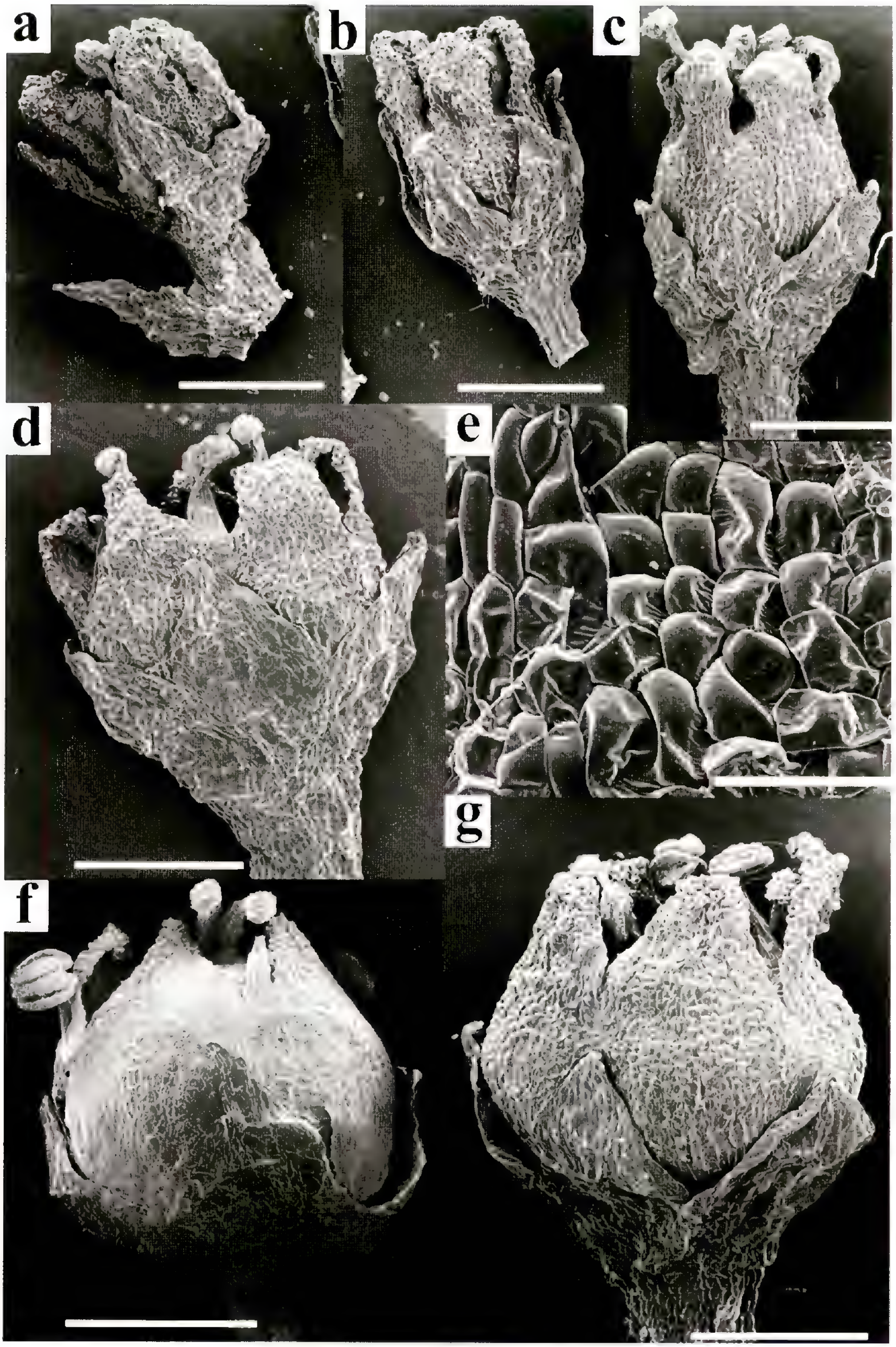


FIG. 2. Floral variation in *C. coryli*: **a–g.** excepting e (scale bar = 1 mm); **e.** Convex fleshy epidermis cells in the corolla (scale bar = 150 μm).

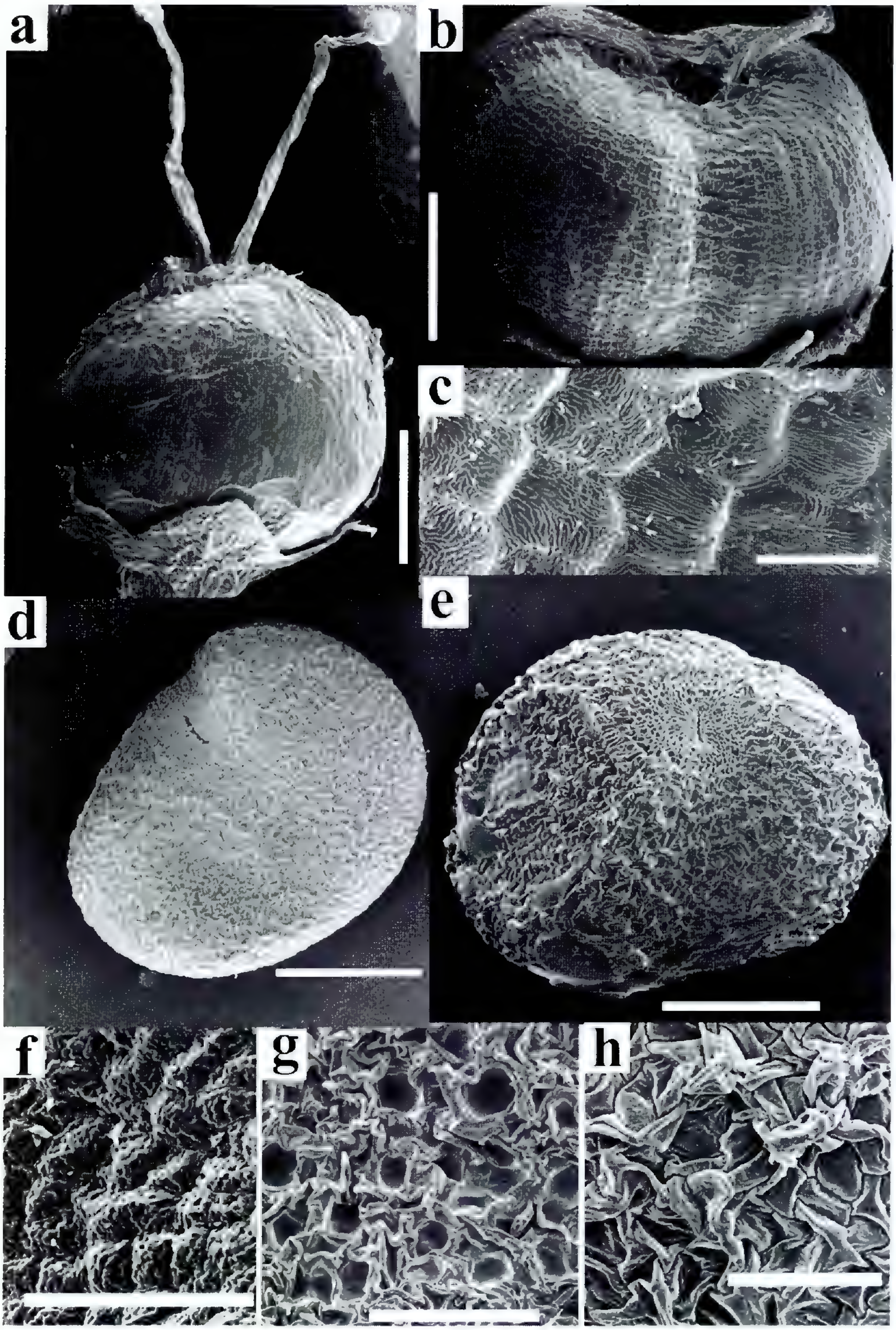


FIG. 3. Capsules and seeds of *C. indecora* and *C. coryli*. **a.** Capsule of *C. indecora* (scale bar = 1 mm); **b.** Capsule of *C. coryli* (scale bar = 1 mm); **c.** Surface of capsule of *C. coryli* (scale bar = 70 μm); **d–e.** Variation of seeds of *C. indecora*: **d.** Dorsoventrally compressed; **e.** More or less angled (scale bar = 0.60 mm); **f–g.** Surface of dry seeds: **f.** *C. coryli*, polygonal with epicuticular wax; **g–h.** *C. indecora*: **g.** Alveolate; **h.** Polygonal with groups of papillose cells (scale bars =200 μm).

a prominent pattern of polygonal cells. **Seeds** 3–4 per capsule, 1.32–1.65 × 1.25–1.4 mm, similar to those of *C. indecora*; additionally seed coat with polygonal epidermal cells may have epicuticular wax as in Fig. 3f. ***2n*** = ?

Distribution and ecology.—"Throughout the United States east of Rocky Mountains, but less common southward and westward" (Yuncker 1965). **CANADA:** Manitoba, Ontario, Québec, Saskatchewan. **U.S.A.:** Alabama, Arkansas, Arizona, Connecticut, District of Columbia, Delaware, Iowa, Illinois, Indiana, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Virginia, Wisconsin, West Virginia.

The floristic record from Québec is new, based on a single collection: QUÉBEC, Chambly Co.: St. Lambert, 9 Aug 1935, *Terrill 884* (MTMG). The species is considered "critically imperiled" (S1) in Canada (Argus & Pryer 1990; NatureServe 2004). Flowering Aug–Oct. **Hosts:** wide range of herbaceous and woody species, including *Aster*, *Ceanothus*, *Corylus*, *Helianthus*, *Monarda*, *Rhus*, *Rubus*, *Solidago*.

Conservation status.—S2S3 (imperiled to vulnerable) in the U.S.A. (not yet assessed by NatureServe 2004); critically imperiled (N1) in Canada (Argus & Pryer 1990; NatureServe 2005).

3. Cuscuta warneri Yuncker, Brittonia 12:38. 1960 (**Fig. 4.**). TYPE: U.S.A. UTAH. Millard Co.: vicinity of Flowell, 15 mi W of Fillmore, on *Phyla cuneiformis*, 10 Sep 1957, *Warner s.n.* (HOLOTYPE: UTC; ISOTYPES: DAO, DPU, GH, NY, OSC, RSA, US, WSU).

Stems 0.30–0.50 mm thick, yellow. **Inflorescences** of subsessile flowers on glabrous pedicels, 0.5–1 mm, in few-flowered glomerules; bracts one at the base of pedicels, ovate to lanceolate. **Flowers** 5-merous, 2.1–4 mm long, slightly fleshy, white-creamy, papillate-hispidulous, corolla epidermis with papillae 30–50µm long oriented in rows; epicuticular wax consisting from longitudinally reticulated rodlets; laticifers isolated or in longitudinal rows as in *C. indecora*. **Calyx** campanulate-cupulate, ca. 1/2 the corolla length, divided ca 1/2, lobes triangular-ovate, carenate, each apically enlarged to form a large, prominent, divergent, horn-like projection, 0.5–0.75 mm long, and sometimes basally with a smaller multicellular projections; not overlapping. **Corolla** tube campanulate-urceolate, 1.7–2.5 mm long, lobes triangular-ovate, more or less auriculate, acute, 0.5–0.7 mm long, 1/3–1/4 the corolla length, suberect, apically inflexed and basally overlapping. **Stamens** included, incurved over the ovary, anthers broadly elliptical 0.4–0.7 × 0.3–0.4 mm; filaments about as long as the anthers; pollen as in *C. indecora*. **Infrastaminal scales** ca. reaching the filaments, united with the corolla tube for ca. 1/2 of their length, oblong, shallowly and irregularly toothed at the truncate apex. **Styles** distinct, 0.2–0.4 mm, evenly filiform, barely longer than the collar-like stylopodium; stigmas globose, capitate. **Capsules**

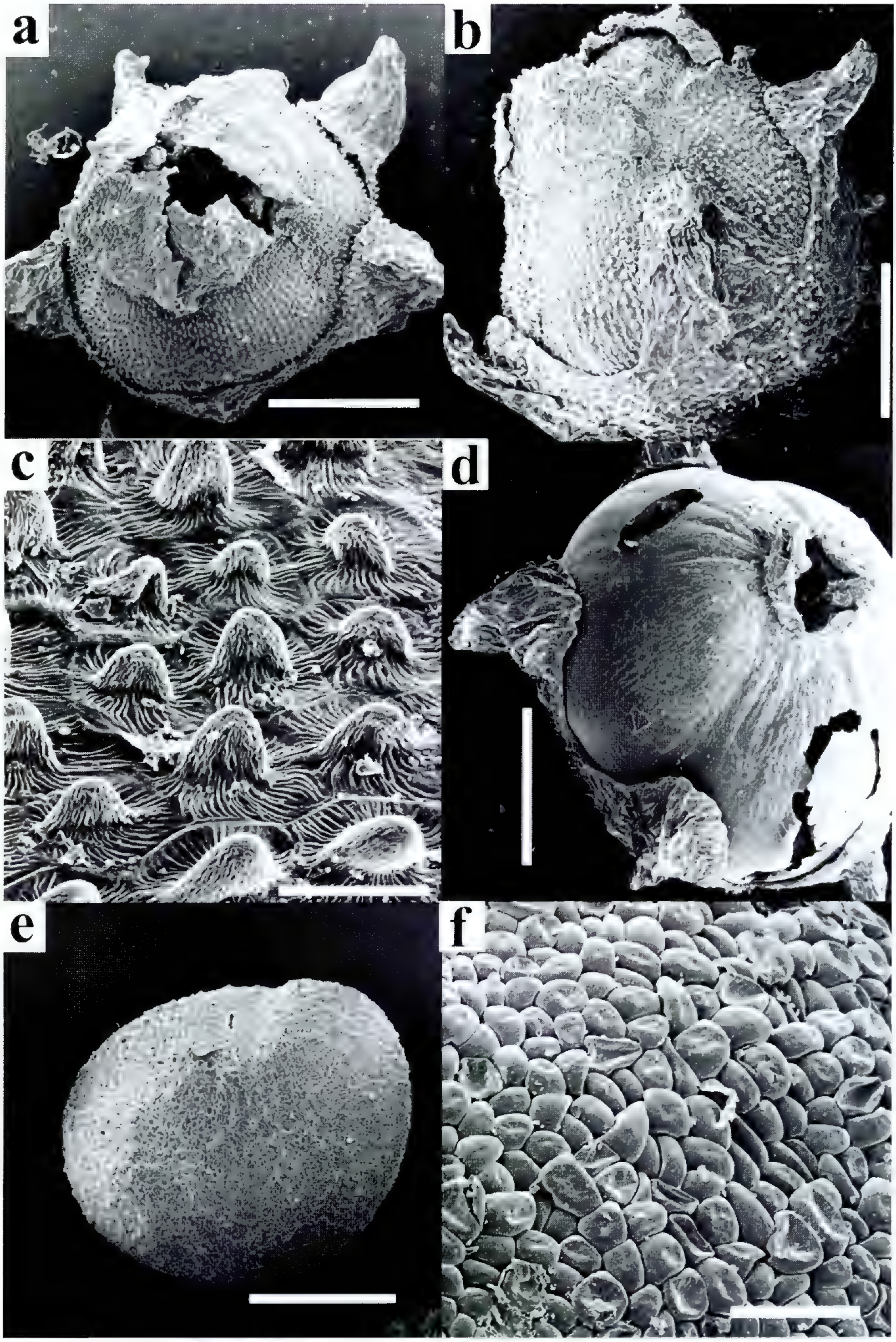


FIG. 4. *Cuscuta warneri*. **a–b.** Morphology of flowers: **a.** Apical view; **b.** Lateral view (scale bars = 1 mm); **c.** Papillae on corolla (scale bar = 75 μm); **d.** Capsule with persistent calyx at base (scale bar = 1 mm); **e–f.** Morphology of seeds: **e.** Seed, ventral view (scale bar = 0.60 mm); **f.** Surface of hydrated seed epidermis (scale bar 75 μm).

yellowish, ± semi-transparent when dried, more or less papillose, globose, 0.9–1.2 wider than long, the suture line between the 2 carpels not depressed; thickened and raised around the style base, indehiscent or irregularly dehiscent, enveloped by the corolla; pericarp epidermis smooth, with scattered papillae 10–20 µm long. **Seeds** 2 per capsule, 1.33–1.56 × 1.26–1.40 mm, dorsoventrally compressed, subround to broadly-elliptic, hilum subterminal, round 0.15–0.18 mm in diameter, vascular scar, 0.04–0.08 mm long, linear, oblique; surface of the seed coat alveolate when dry and papillose when wet, seed epidermis cells 0.26–0.40 µm in diameter. ***2n*** = ?

Distribution and ecology.—**U.S.A.:** The species has been considered "possibly extinct" because despite repeated search it has never been found again at the type locality in Utah (Reveal & Cronquist 1984; NatureServe 2005). However, we have found one more collection from southern New Mexico (Sierra Co.: Pedro Armendaris Grant, 15.6 mi N of Engle, E of Red Lake, 4800 ft, on *Phyla incisa*, 24 Sep 1998, *Peterson 98-699* (NMC)). The species has also been mentioned from Arizona (NatureServe 2005), but we are not aware of any herbarium vouchers. Albeit clearly extremely rare and endangered, this species might be potentially distributed at a low frequency over a larger geographic range, spanning Utah, Arizona, and New Mexico. Flowering and fruiting Jul–Sep. **Hosts:** known only from *Phyla* sp.

Conservation status.—T1 (critically imperiled) (GH, presumed extinct, NatureServe 2005).

4. Cuscuta jepsonii Yuncker, Illinois Biol. Monogr. 6:149. 1921. **(Fig. 5).** TYPE: U.S.A. CALIFORNIA: Big Horse Mountain, South Fork of Eel River, 3 Aug 1892, *W.L. Jepson 5c* (HOLOTYPE: JEPS, fragment NY).

Stems 0.30–0.40 mm thick, pale-yellow. **Inflorescences** of short-pedicellate flowers in cymose clusters; bracts one at the pedicel base, ovate to lanceolate. **Flowers** 5-merous, 2–2.7(–3) mm long, fleshy, white-cream; epidermal cells arranged in rows, fleshy, with anticlinal walls convex (dome-like), additionally with cylindric-conical papillae 40–70 µm long; when flowers dry up, rows of dehydrated epidermal cells are usually easily discernible; epicuticular wax represented by longitudinally reticulated rodlets; laticifers isolated ovoidal to elongated, or arranged in longitudinal rows, present in the perianth along the midveins, ovary and capsules often running longitudinally and yellowish-orange colored. **Calyx** shallowly cupulate, ca. 1/2 as long as the corolla tube, divided ca. 1/2 the length, lobes triangular, acute, not basally overlapping. **Corolla** tube campanulate-globular, becoming suburceolate, 1.3–2 mm long, lobes triangular, acute, less than 1/2 as long as the tube, erect, with inflexed apices. **Stamens** mostly included, anthers broadly elliptical 0.2–0.3 × 0.1–0.2 mm long; filaments about as long as the anthers; pollen as in *C. indecora*. **Infrastaminal scales** lacking or represented only by ridges and short bridges. **Styles** 0.4–0.8

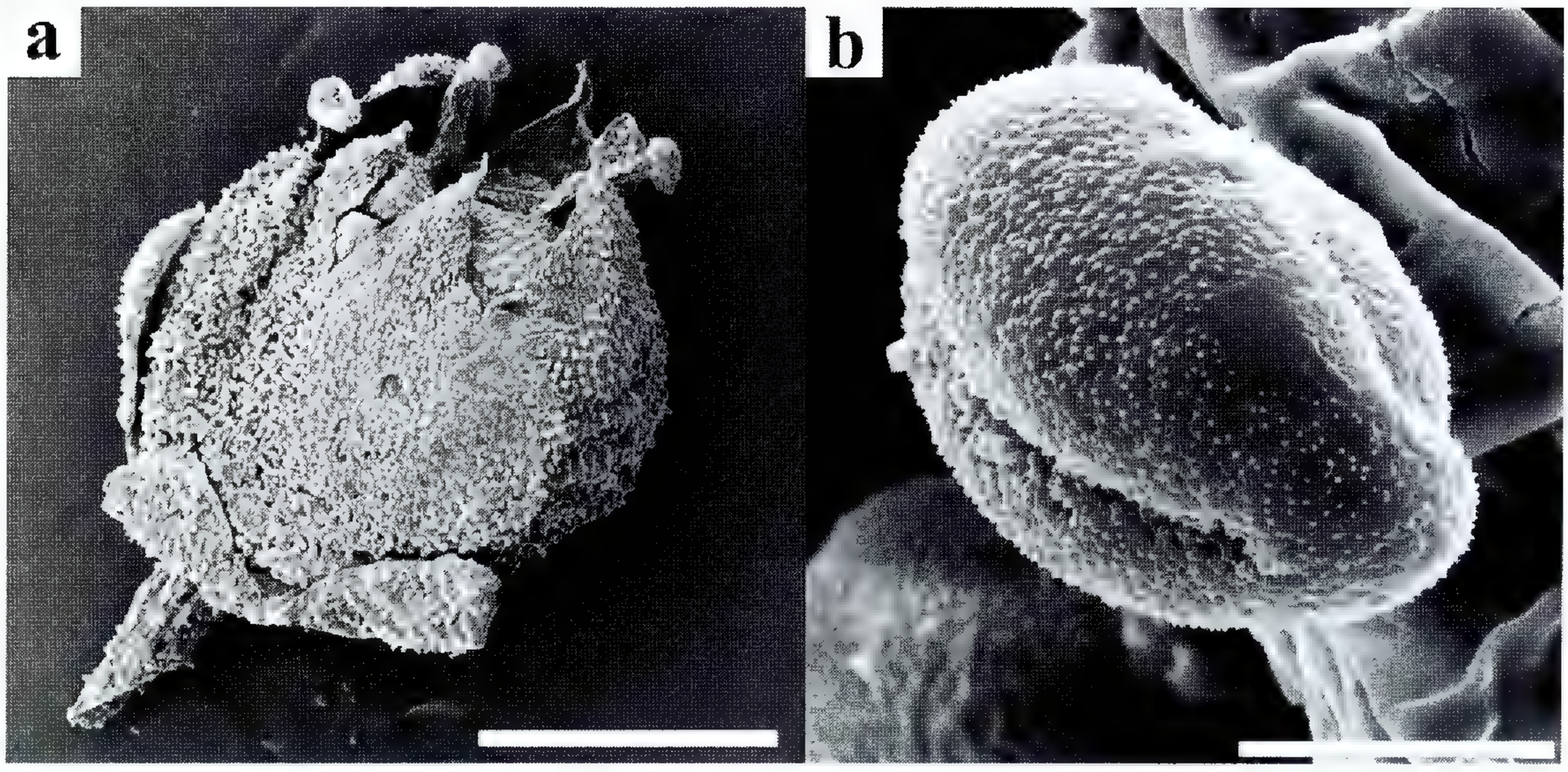


FIG. 5. *Cuscuta jepsonii*. **a.** Flower (scale bar = 1 mm); **b.** Pollen (scale bar = 10 μm).

mm long, ± unequal, somewhat subulate, erect or divergent in capsule; stigmas capitate, globose. **Capsules** light-brown ± semi-transparent when dried (pericarp thin), glabrous, subglobose, globose, to slightly depressed-globose, 1–1.5 wider than long, narrowed and thickened around the style bases, indehiscent or irregularly dehiscent, surrounded by the withered corolla. **Seeds** (no mature seeds were seen) 2–4 per capsule. ***2n*** = ?

Distribution and ecology.—Known only from the type collection. Flowering summer–early fall (Jul–Sep). **Hosts:** *Ceanothus.*

Conservation status.—GH (presumed extinct) (not mentioned in NatureServe 2005).

APPENDIX 1.—VOUCHERS FOR THE SEM STUDY (NY, EXCEPT *C. WARNERI* FROM GH AND *C. JEPSONII* FROM UC)

1a. Cuscuta indecora var. indecora (19 collections examined). —**U.S.A. ARIZONA. Pinal Co.:** Superior, Gloke Hwy, July 1926, *Moore s.n.* **CALIFORNIA. Kern Co.:** Bakersfield, 400 ft, 6 Jul 1920, *Fisher s.n.* **San Bernardino Co.:** San Bernardino Mts., lower edge of Upper Sonoran Zone, 4000 ft, 9 Nov 1932, *Wolf 4392*. **COLORADO. Larimer Co.:** Fort Collins, 5000 ft, 25 Aug 1896, *Baker s.n.* **FLORIDA. Putnam Co.:** 2.5 mi S of San Mateo, 26 Jul 1961, *Godfrey & Reinert 61139a.* **IDAHO. Gooding Co.:** Hagerman Valley, 13/E, 7S, 21 Aug 1941, *Davis 4306.* **Elmore Co.:** 2 mi E of Glenns Ferry, 23 Aug 1940, *Christ 11779.* **LOUISIANA. Terrebone Parish**: around Louisiana Universities Marine Consortium lab buildings and along La. 56 in Cocodrie, S of Houma, T21S, R18E, 12 Aug 1989, *Thomas 111952.* **MISSISSIPPI. Harrison Co.:** Ship Island, 15 Jun 1952, *Demaree 31920.* **NEBRASKA. Arthur Co.:** Arapaho Prairie, T18N R39W Sect 31, 32, ca. 1200 m, 27 Jul 1977, *Vescio & Kruse 174.* **NEVADA. Nye Co.:** Rt. 52 near Rt. 16 junction, 2600 ft, 26 Sep 1970, *Beatley s.n.* **NEW MEXICO. Chaves Co.:** Bottomless Lakes State Park at the edge of Pasture Lake, 5 Oct 1966, *Crutchfield 2319.* **Eddie Co.:** a few m N of Texas border ca. 0.5 mi SE of Hwy. 62-180, ca. 3900 ft, 1 Sep 1985, *Spellenberg & Spurrier s.n.* **OREGON. Umatilla Co.:** near Hermiston, 29 Jul 1944, *Peck 22633.* **TEXAS. Angelina Co.:** near Shawnee, 10 Sep 1942, *Lundell & Geiser 11905.* **El Paso Co.:** along Hwy. 62-180, 4 mi E of junction with Hwy 659, ca

4000 ft, 23 Oct 1983, *Worthington 11583*. **Llano Co.:** hills above Inks Dam, 21 May 1940, *Lundell & Lundell 9025*. **UTAH. Utah Co.:** T10S, Sec. 4, 0.5 mi E of Genola turnoff on Hwy 50-6, 4650 ft, 8 Sep 1984, *Baird et al. 1513*. **Weber Co.:** Howel Experimental Fruit Farm, Pleasant View, N Ogden, 7 Sep 1967, *Nye s.n.*

1b. Cuscuta indecora var. longisepala (2 collections examined).—**TEXAS. Chambers Co.:** Anahuac, 3 ft, 10 Jun 1933, *Fisher s.n.* **Cameron Co.:** 4 mi NW of Brownsville, bordering the Military Hwy, 10 m, 9 Jul 1941, *Runyon 2819*.

1c. Cuscuta indecora var. attenuata (3 collections examined).—**KANSAS. Republic Co.:** 2 mi N and 2 mi W of Wayne, 13 Sep 1952, *Horr 4410*. **TEXAS. Cameron Co.:** Robb's Ranch, 0.5 mi N of Ranch house, bordering the road, 10 Aug 1941, *Runyon 2873*. **Dallas Co.:** Dallas, Sep 187(?4), *Reverchon s.n.*

2. Cuscuta coryli (17 collections examined).—**CANADA. ONTARIO(?)**: St. Clair River (?), Squirrel Island, 16 Sep 1920, *Farwell 5692*. **U.S.A. ARIZONA. (no county given):** Grand Canyon, 7 Sep 1886, *Eggert s.n.* **ILLINOIS.** Menard(?), no date, *Hall s.n.* **INDIANA. Lake Co.:** just S of Pine, 19 Sep 1926, *Deam 43763*. **Nobble Co.:** 4 mi N of Kendallville, 23 Aug 1928, *Deam 46128*. **MARYLAND. Montgomery Co.:** wood near Widewaters, 26 Aug 1934, *Killip 31293*. **MICHIGAN. Kalamazoo Co.:** 4 m NE of Schoolcraft, 6 Sep 1938, *Hanes 548*. **MISSOURI.** St. Louis, Sep 1842, *Engelmann s.n.* **Bush Co.:** Eagle Rock, 28 Sep 1896 and 14 Aug 1905, *Bush 202 and 3244*. **NEBRASKA. Richardson Co.:** woods of Lee's Ranch, 1.5 mi NW of Fargo, 1000 ft, 15 Sep 1940, *Reynolds 2727*. **NEW JERSEY. Somerset Co.:** Second Mountain, Watchung, 29 Aug 1937, *Moldenke 10086*; Little Snalie Hill, Sep 1915, *MacKenzie 6772*. **NEW YORK. Tioga Co.:** Campville, 20 Sep 1895, *collector illegible (F.E. Fr...) 296*; Long Island, Sea Cliff, 24 Sep 1928, *Ferguson 7181*; Staten Island, 24 Oct 1891, *Vail s.n.* **TENNESEE. Carter Co.:** Roan Mountain Station, 28 Aug 1908, *Rydberg 8179*. WISCONSIN. Madison, no date, *Watson s.n.*

3. Cuscuta warneri (1 collection examined).—**U.S.A. NEW MEXICO. Sierra Co.:** Pedro Armendaris Grant, 15.6 mi N of Engle, E of Red Lake, 4800 ft, on Phyla incise, 24 Sep 1998. *Peterson 98-699* (NMC). **UTAH.** The type collection (GH).

4. Cuscuta jepsonii (1 collection examined).—**U.S.A. CALIFORNIA.** The type collection (UC).

ACKNOWLEDGMENTS

We thank directors/curators from ACAD, ALTA, ARIZ, ASU, BRIT, DAO, F, GH, HAM, MEXU, MICH, MT, MTMG, NFLD, NSPM, OAC, QFA, QUE, RBG, RSA, SASK, SFS, TEX & LL, TUP, UBC, UC & JEPS, UNB, UNM, US, USAS, UWO, UWPG, WAT, WIN, WIS, WTU, and XAL for loans to Costea. Special thanks to NY staff for approving and preparing the four voluminous loans containing the herbarium of T.G. Yuncker. Dan Austin, Alan Prather and Lytton Musselman provided valuable comments and suggestions for an earlier version of the manuscript. Special appreciation goes to Therry Deroin (P) for sending the fragments of the *Cuscuta indecora* type and to Barbara Ertter (UC) and Emily Wood and Walter Kittredge (GH) for permission for SEM study of the types of *C. jepsonii* and *C. warneri*. Alexandra Smith assisted us with the scanning electron microscope. Elma Schweigert translated the abstract into Spanish.

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Book Review

Richard C. Beidleman. 2006. **California's Frontier Naturalists.** (ISBN 0520230108, hbk.). University of California Press, Berkeley. (**Orders:** California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A. Tel: 609-883-1759; Fax 609-883-7413). $39.95, 484 pp., b/w illus., map, 5 1/2" × 9 1/2".

In this well-written and very readable book, Dr. Beidleman offers the history of California natural history exploration through the lives of those men and women who ardently and assiduously observed and collected throughout the state. They sought and they found the unknown, new species never before described. Data of their lives, their backgrounds, and their motives are detailed. Their personalities are revealed by anecdotal passages, some no more than a sentence or two, some lengthy.

Coverage begins with exploration around Monterrey in 1786 by the Conte de La Pérouse under the French flag and ends in the early twentieth century with the remarkable John and Sarah Lemmon and Kate Brandegee. In between are numerous explorers assigned to the boundary and railway surveys and particularly the prodigious California Geological Survey (1842–1874). Some of the scientist explorers were instrumental in the establishment of such institutions as the University of California, Berkeley, the California Academy of Sciences, and the Lick Observatory.

While references include the whole range of biology, geology, and astronomy, many of these frontier naturalists were botany-minded. Their findings included hundreds of new species which were sent to George Engelmann, Asa Gray, and John Torrey. The author names many of these plants, usually with the scientific name or with enough description to place the plant in its family. However, those not versant in California flora might be advised to have on hand a field guide if not the Jepson manual for such citations as "the Pale-Yellow Layia," or the "poisonous prickly poppy, Chicolote."

In this book one meets fascinating characters whose names may not be in common parlance but are familiar in scientific language: *Asarum lemmonii, Carex breweri, Baccharis plummerae, Lilium parryi, Tritonia palmeri* among many.

If John Muir seems to have been granted relatively short shrift, the author certainly recognizes his participation and his accomplishments in conservation and preservation. In general Dr. Beidleman features those naturalists who contributed significantly in scientific discovery.—*Joann Karges (retired TCU Library), Botanical Research Institute of Texas, Fort Worth, TX 76102-4060, U.S.A.*

A NEW SPECIES OF *PEDIOMELUM* (FABACEAE) FROM THE LOWER PIEDMONT PLATEAU OF GEORGIA AND SOUTH CAROLINA

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ABSTRACT

In the Piedmont Physiographic Province of the southeastern U.S.A., the endemic North American genus *Pediomelum* is known only from three dry, rocky, partly open sites near the Fall Line. The first collections were made in 1984, from Richland County, South Carolina; in 1996, from more than 100 km. to the west, in Columbia County, Georgia; and in 2005, from Lexington County, South Carolina, less than 20 km from the Richland County site. The two late-twentieth-century collections were referred, with reservations, to *P. canescens*, a species of sandy soils on the adjacent Atlantic Coastal Plain. This was the only known *Pediomelum* that resembled the Piedmont plants in having the petioles shorter than the petiolules and the only similarly erect and caulescent species east of the Mississippi River. Subsequent collections and study by the authors indicate that the Piedmont populations share a consistent morphology that is unique within the genus in combining subsessile leaves with congested, many-flowered inflorescences. These plants differ from *P. canescens* in additional ways (e.g., fruiting calyces gibbous and more narrowly campanulate, bracts conspicuously larger and broader, and leaflets more narrowly elliptic). The Piedmont plants also cannot be considered a sessile-leaved variant of any of the western species, and therefore they are described as *Pediomelum piedmontanum* Allison, Morris, & Egan, sp. nov.

RESUMEN

En la Provincia Fisiográfica de Piedmont del sureste de EEUU, el género *Pediomelum*, endémico de Norteamérica, se ha encontrado solamente en tres sitios secos y rocosos y parcialmente abiertos que están cerca de la Fall Line. Las primeras colecciones se hicieron en 1984 en el Condado de Richland, Carolina del Sur; en 1996, a más de 100 km al oeste, en el Condado de Columbia, Georgia, y en 2005 en el Condado de Lexington, Carolina del Sur, a menos de 20 km del sitio en el Condado de Richland. Las dos colecciones de finales del siglo XX se refirieron, con reservas, a *P. canescens*, una especie de los suelos arenosos en el Atlantic Coastal Plain contiguo. Este era el único *Pediomelum* conocido que se asemejaba a las plantas del Piedmont en tener los pecíolos más cortos que los peciólulos y la única especie semejante al este del Río Mississippi erguida y caulescente. Las colecciones subsiguientes y los estudios por los autores indican que las poblaciones del Piedmont comparten una morfología coherente que es única dentro del género en combinar las hojas subsésiles con las inflorescencias congestas y multiflloras. Estas plantas se diferencian de *P. canescens* de otros modos (p. ej., los cálices fructíferos gibosos y más angostamente campanulados, las brácteas visiblemente más grandes y más

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anchas, y las hojuelas más angostamente elípticas). Las plantas del Piedmont tampoco se pueden considerar como una variante, con las hojas subsésiles, de cualquiera de las especies occidentales, y por lo tanto se describen como *Pediomelum piedmontanum* Allison, Morris, & Egan, sp. nov.

HISTORICAL SKETCH

"This specimen is an enigma." So began Duane Isely (1918–2000) in his 1991 annotation of *J.S. Angerman s.n.* (USCH), a South Carolina specimen whose original label bears a date (June 8, 1984) but lacks any name for the plant. Above this label is an annotation slip with James Grimes' 1991 determination as *Pediomelum cuspidatum* (Pursh) Rydb., made the year after publication of his monograph (1990) of *Pediomelum* Rydb. and other genera of New World legumes often treated at the time as components of a single broadly-defined genus, *Psoralea* L. Grimes' determination of *Angerman s.n.* as *P. cuspidatum* must have preceded Isely's annotation, which was manifestly written in dissent:

> This specimen is an enigma. It is not *Pediomelum cuspidatum*, which is a species of the Great Plains. The leaves of *P. cuspidatum* are petioled and 3–5 foliolate. These are sessile and 3-foliolate. The only *Pediomelum* currently known in South Carolina is *P. canescens*. It matches this to the extent that the leaves are shortly petioled or subsessile, but the inflorescence is entirely different.

Clearly as a result of seeing these remarks, Grimes took another look at *Angerman s.n.*, making some floral dissections and measurements of the parts (as recorded in pencil drawings on the sheet) that were the basis for his second annotation, which he attached above Isely's, with reasons why the specimen also did not fit typical *Pediomelum canescens* (Michx.) Rydb. (pubescence, leaf shape, number of floral nodes, length of lower calyx-tooth and of wing-petals). Before concluding this annotation with the results of his floral dissection, Grimes wrote that the plant probably merits varietal rank. We assume he meant under *P. canescens*, since he confined his comparison to that species, *sensu stricto*, though his unelaborated determination of three months earlier as *P. cuspidatum* was not explicitly retracted.

In 1996, five years after the Isely and Grimes annotations but without knowledge of them, Thomas S. Patrick of the Georgia Natural Heritage Program (GNHP) made the next known collection of a *Pediomelum* from the Piedmont Plateau (*Patrick s.n.*, GA, NY). It came from a locality with unusual geology (serpentinite and related rocks) near the Savannah River in Columbia County, Georgia. Patrick identified the legume using Radford et al. (1968), in which, due to the palmately foliolate and essentially sessile leaves, it keys to *Psoralea canescens* Michx. (= *Pediomelum canescens*), a species known from the nearby Atlantic Coastal Plain sandhills of Georgia and South Carolina, as indicated in Radford et al. That the habitat of *Patrick s.n.* was a rocky place in the Piedmont did not militate against such an identification, as the site supports a natural community with a mix of Piedmont and Coastal Plain flora. Among the latter are *Pinus palustris* P. Mill. (longleaf pine), very rare in the eastern two-thirds of

the Piedmont of Georgia, and *Marshallia ramosa* Beadle & F.E. Boynt. (Asteraceae), a state-protected rarity otherwise endemic to the Coastal Plain.

In June 1999 Morris encountered this same Georgia population of *Pediomelum* and collected *Morris 4558* (Herbarium of North Georgia College and State University, "NGCSU"). At the time, he was unaware of both the 1984 specimen at USCH and Patrick's *Pediomelum* collection (then stored at GNHP). After trying to identify his collection using Isely (1990) and finding that, because of the leaf shape and dense inflorescences (Figs. 1, 2), the plant did not key straightforwardly to any species, Morris showed his collection to Allison, who had the benefit of familiarity with *P. canescens*. Noting at once the much showier inflorescences and proportionately narrower leaves of Morris' collection, Allison believed it must either represent a new species or a long-range disjunct. After obtaining the two most recent monographs of the group (Ockendon 1965; Grimes 1990), Allison, Morris and Patrick agreed that the plants appeared to represent a new species. An abstract reporting these findings, but without knowledge of the specimen from South Carolina, indicated the intention to name the new species *Pediomelum georgianum* (Allison et al. 2003).

In 2004 Egan undertook a study of the phylogenetics, biogeography, and diversification of North American Psoraleeae (Egan & Crandall 2005). In advance of field sampling of the group, she made inquiries about localities with recent collections or observations of the various taxa. While inquiring about South Carolina localities for *Pediomelum canescens*, Egan was alerted by the curator of USCH, John Nelson, about the "enigmatic" South Carolina collection. After borrowing it, she agreed with Isely and Grimes that it was not a clear match for any described taxon and sought out the actual living plants. In June 2005, Egan found the plant at the likely original collection site, in Richland County, and also discovered a population about 19 km away in Lexington County. The consistent and distinctive morphology confirmed her suspicion that it was a new species. Internet research led her to a listing (GNHP 2004) of an undescribed *Pediomelum* on a roster of Georgia rare plants, resulting in her contacting Allison.

After comparison of all the known specimens of Piedmont *Pediomelum*, from *Angerman s.n.* through Allison's September 2005 collections of the first fruiting material from the South Carolina sites, we have concluded that these occurrences of *Pediomelum*, one in Georgia and two in South Carolina (Fig. 3), are all of the same, undescribed species, with a provisional *nomen nudum* of *P. georgianum*. The delay in formal description permits us to give the new species a more appropriate specific epithet:

Pediomelum piedmontanum J.R. Allison, M.W. Morris & A.N. Egan, sp. nov. (**Fig. 2**). TYPE: UNITED STATES. GEORGIA. Columbia Co.: ca. 12 km NE of Appling. Dixie Mountain, 20 Jul 2001, *James R. Allison & Michael Wayne Morris 12764* (HOLOTYPE: NY; ISOTYPES: BRIT, BRY, FLAS, GA, GH, MISS, MO, NGCSU, NLU, NY, PH, US, USCH, VSC).



FIG. 1. Upper portion of a plant of *Pediomelum piedmontanum*, with the characteristic dense, many-flowered inflorescences and leaves all more than twice as long as wide. Columbia County, Georgia, 15 Jun 2002.

Inter species Pediomeli subgeneris Pediomeli sensu Grimesii petiolis brevioribus quam petiolulis ad P. canescens solum accedit, autem simul est P. reverchonio soli simile bracteis floralibus magnis et latissimis et valde caudatis, sed ab ambobus statim distinguitur inflorescentiis densis et multifloris.

Plant an erect, strigose and glandular-punctate perennial herb 0.5–0.8(–1) m tall; root deep, woody, fusiform, branching, rough-furrowed, to at least 1.5 cm wide × 15 cm long (Fig. 4D). **Stems** each senescing and detaching at ground level promptly after maturation of fruit, including the persistent infructescence; in life 1–few, to 6 mm in diameter, branching usually a little below the middle, with exfoliating scaly epidermis below, sometimes purplish toward base, strigate, blond to dark brown punctate-glandular, and strigose (hairs 0.4–0.9 mm long), often with remnants of cataphylls, these usually only one or two, remote, and some distance from base, 6–10 mm wide × 6.5–9 mm long, obviously veined, sometimes bifid. Stipules erect, persistent, linear-lanceolate, 7–12 mm long × 6.5–9 mm wide, papery, very sparingly strigose, obviously veined, the lower ones sometimes fused-free, free above. **Leaves** palmately 3(–5)-foliolate (Figs. 1, 2, 4B); petiole (0–)1–2.4(–4) mm long (reduced upward), terete to more usually slightly canaliculate, sparingly strigose, not jointed to the stem and not swollen at the



FIG. 2. Holotype of *Pediomelum piedmontanum*, prior to its deposit at NY.

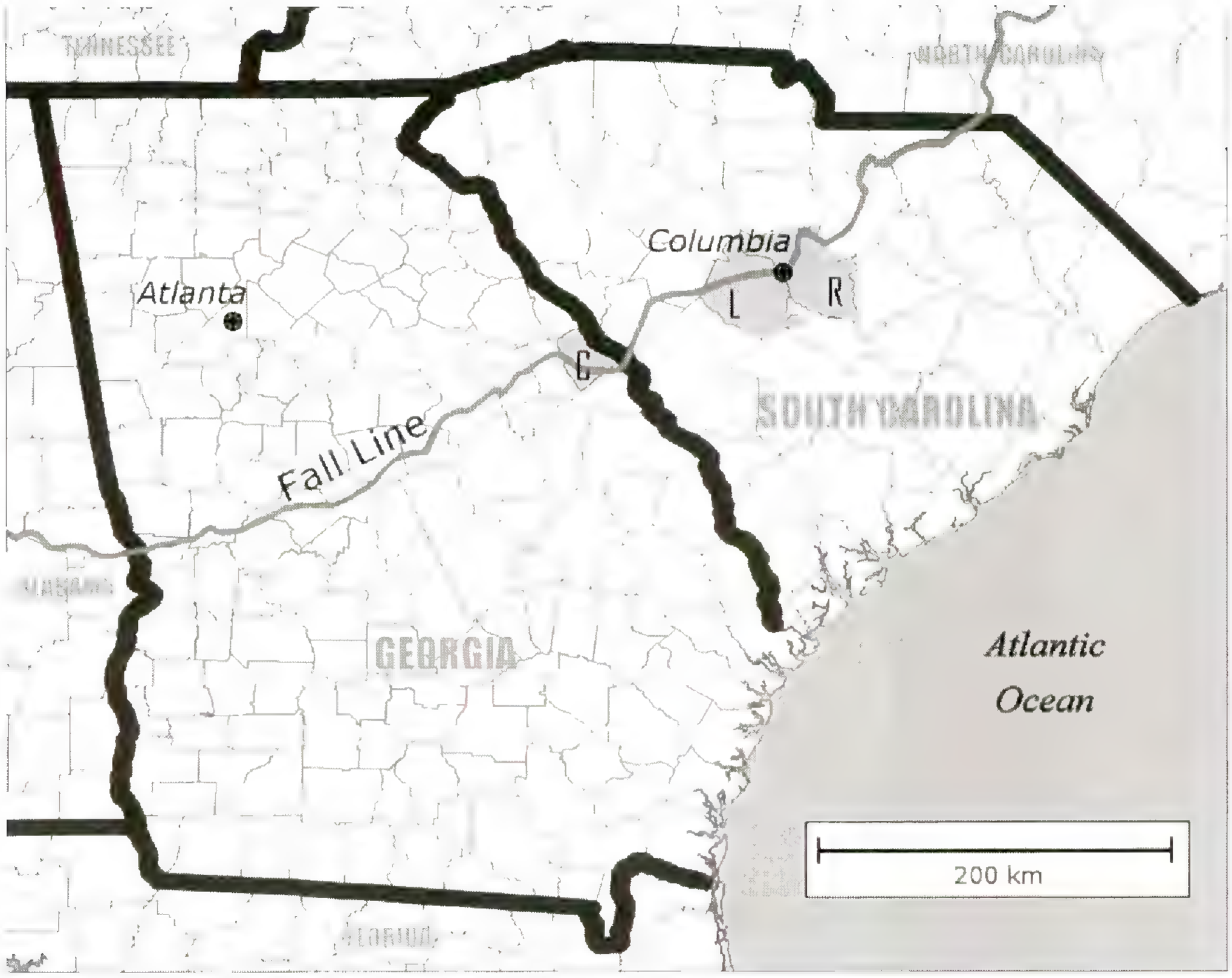


Fig. 3. County outline map showing Georgia, South Carolina, their capital cities, and portions of adjacent states. Counties with known occurrences of *Pediomelum piedmontanum* (all north of but near the Fall Line) are marked with the first letter of the county name (Columbia, Lexington, Richland) and shaded. Based on a county outline map of the southeastern U.S.A., downloaded from http://www.amaps.com/, with the approximate location of the Fall Line traced from Physical Map of the Southeast, copyright 1967 by Wilbur H. Duncan.

base, shorter than petiolules or petiole lacking and petiolules attached directly to leaf spur; petiolules usually darker in color than petiole, strigillose, 1.8–3 mm long; leaflets narrowly to broadly elliptic, (0.4–)0.6–2.7 cm wide × (1.0–)1.2–5(–5.5) cm long, apex rounded or shallowly retuse, often mucronate, basally cuneate, strigose-ciliate, upper surface sparingly strigose, especially on midvein, lower surface usually slightly paler and more abundantly strigose, both surfaces densely dark-glandular. **Inflorescence** a dense, many-flowered pseudoraceme, in outline [ovate or] elliptic to oblong, (2.1–)2.5–5.7 cm long, with (4–)6–13(–15) nodes and (1–)3(–4) flowers per node; peduncle 0.6–2.8(–3.4) cm long, base of same color and texture, not jointed to stem; rachis (1–)2–5(–5.5) cm long, elongating only slightly in fruit, usually some or most of the nodes in subopposite pairs, internodes (0.5–)1–6(–10) mm in length; bracts conspicuous, enclosing the calyx, persistent, broadly ovate to suborbicular, caudate at apex, body 8–11.5 mm wide × (7–)9–10 mm long, densely amber- to dark

brown-glandular in age, often purplish-tinged distally, especially the 4.5–7(–8) mm long tail; pedicels 1.1–3 mm long, pubescent. **Flowers** (Fig. 4A) 12.5–14 mm long; calyx (10–)12–13 mm long to upper teeth, 12–16 mm to lower tooth, the tube green or sometimes suffused with violet, 4–5 mm long, nearly glabrous internally, externally more or less pilose, at least below the lower tooth, and amber- to dark brown-glandular except for the gibbous area, sometimes largely eglandular except along the vein running into each of the upper and medial teeth, the teeth linear-lanceolate, darker green and often tinged with violet, at least distally, copiously pilose-ciliate proximally and sparsely so distally, the upper four teeth 4–8 mm long × 1–1.5 mm wide, nearly glabrous on both surfaces or internally more or less sericeous, the lower tooth (6–)7–11(–11.5) mm long × 1.5–3 mm wide, internally sericeous, proximally externally pilose, the calyx in fruit strongly gibbous-campanulate, with a vein to the apex of each tooth and one to each sinus, those to the sinuses bifurcating and continuing as submarginal veins more than 3/4 the length of the tooth; petals violet to lavender, or cream to yellowish with tinges of violet on wings and keel; banner obovate or broadly oblanceolate, (8.5–)10–14 mm long × 5.5–7 mm wide, the claw (3.5–)4.5–7 mm long, the blade shallowly emarginate or occasionally truncate, low-biauriculate, the auricles scarcely internally callose; wings (7–)8–12 mm long × 2–2.5 mm wide, the claw (3–)4–6 mm long, the auricle 1–1.5 mm long; keel petals (5–)6–10 mm long × 2–2.5(–3) mm wide, the claw (3–)4–5 mm long, the blade with a darker violet blotch apically, occasionally very slightly apiculate; androecium 9.5–11 mm long, apically calyciform, anthers obovoid-elliptic, 0.5(–0.75) mm long; gynoecium 8–9 mm long, ovary glabrous, style glabrous or sometimes strigillose at the base. **Fruit** body broadly elliptic to slightly obovate in profile, 6–7 mm long × 4–4.5 mm wide, glabrous, densely amber- to dark brown-glandular, narrowed (but not abruptly) to the arcuate beak, which is (5–)6–8 mm long × 2–3 mm wide, glandular like the body, adaxial surface sparsely short-pubescent, distinctly longer than the calyx teeth and strongly exserted (Fig. 4C). Seed weakly reniform, 3.5–5 × 2.5–3.5(–4) mm, compressed but not flattened, nearly smooth, gray-brown (Fig. 4E). **Flowering** late May–late June (–late July), fruiting July–August(–September).

Habitat and range.—Apparently endemic to rocky, open areas and adjacent open woodlands in the lower Piedmont Plateau of Georgia and South Carolina (Fig. 3).

PARATYPES. **U.S.A. GEORGIA. Columbia Co.:** (topotypes): 16 Jun 1996, *Patrick s.n.* (GA, NY); 21 Jun 1999, *Morris 4558* (NGCSU, NLU); 25 Aug 2001, *Allison et al. 13001* (GA); 2 Jun 2002, *Morris 4971* (NGCSU, NLU, SWSL); 15 Jun 2002, *Allison & Morris 13423* (CLEMS); 5 Sep 2002, *Allison 13459* (MO, VSC); 25 Jul 2003, *Allison 13611* (FLAS, GH, NY, US), *Allison 13613* (MICH); 19 Aug 2005, *Morris 5039* (NGCSU); 24 Aug 2005, *Allison & Morris 13777* (NCU); 18 Sep 2005, *Williams & Morris 55* (NGCSU); 27 Sep 2005, *Allison 13813* (AUA, FSU, GA, JSU, PH, TENN, UNA). **SOUTH CAROLINA. Lexington Co.:** 23 km NW of Columbia, 5 Jun 2005, *Egan & Egan 263* (BRY, NY); 25 Sep 2005, *Allison 13800* (BRY,

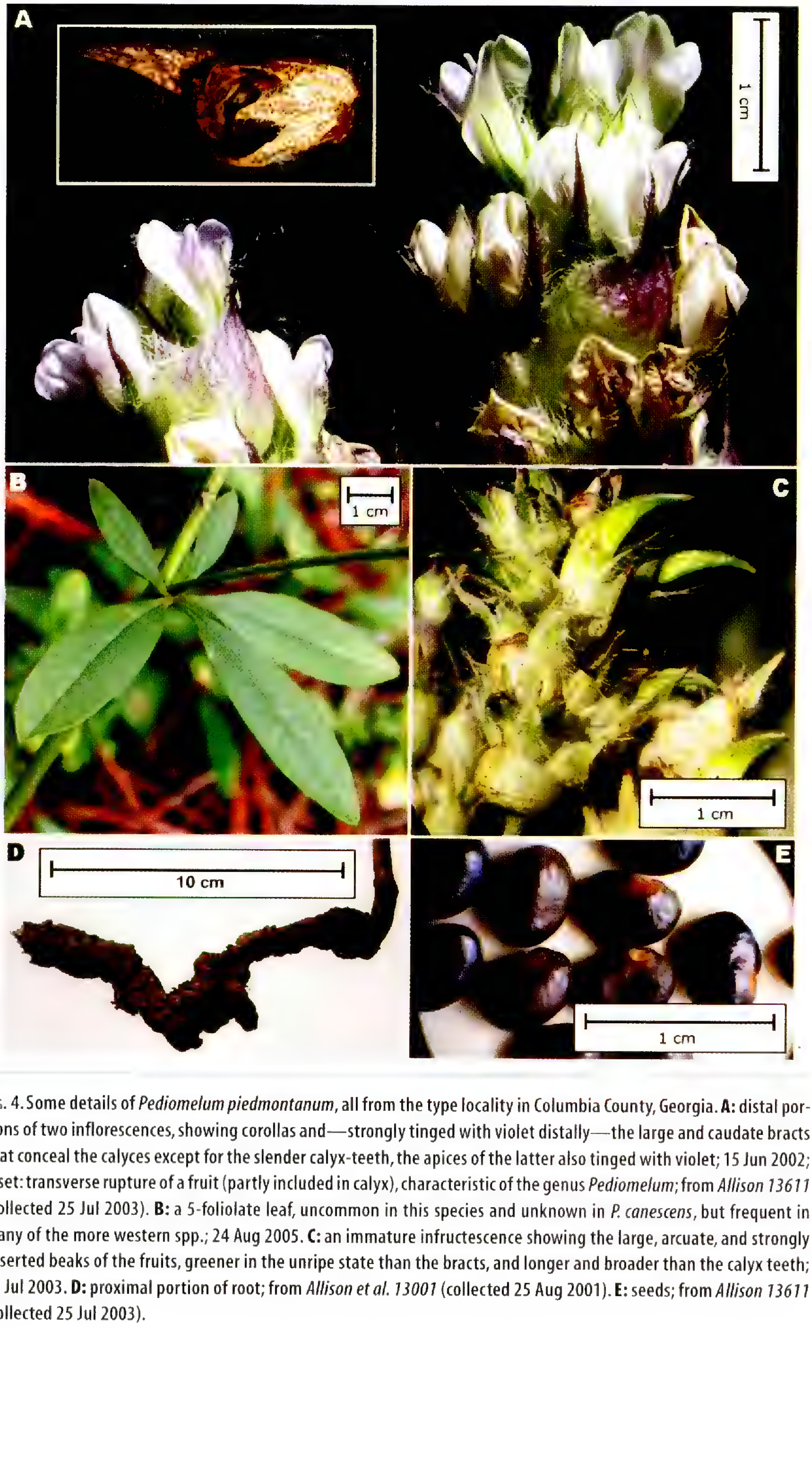


Fig. 4. Some details of *Pediomelum piedmontanum*, all from the type locality in Columbia County, Georgia. **A:** distal portions of two inflorescences, showing corollas and—strongly tinged with violet distally—the large and caudate bracts that conceal the calyces except for the slender calyx-teeth, the apices of the latter also tinged with violet; 15 Jun 2002; inset: transverse rupture of a fruit (partly included in calyx), characteristic of the genus *Pediomelum*; from *Allison 13611* (collected 25 Jul 2003). **B:** a 5-foliolate leaf, uncommon in this species and unknown in *P. canescens*, but frequent in many of the more western spp.; 24 Aug 2005. **C:** an immature infructescence showing the large, arcuate, and strongly exserted beaks of the fruits, greener in the unripe state than the bracts, and longer and broader than the calyx teeth; 25 Jul 2003. **D:** proximal portion of root; from *Allison et al. 13001* (collected 25 Aug 2001). **E:** seeds; from *Allison 13611* (collected 25 Jul 2003).

CLEMS, MO, TAMU, TEX, USCH, VDB); 26 Sep 2005, *Allison 13808* (GH, NY, US). **Richland Co.:** 26 km NW of Lexington, 8 Jun 1984, *Angerman s.n.* (USCH; labeled, apparently in error, as from Lexington County); 5 Jun 2005, *Egan & Egan 262* (BRY, K, NY); 25 Sep 2005, *Allison 13801* (BRIT, CLEMS, NCU, USCH); 26 Sep 2005, *Allison 13803* (BRY).

COMPARISONS WITH CONGENERS

Within the papilionoid legumes (whether treated as a family or subfamily), two tribes, the Psoraleeae (Benth.) Rydb. and the Amorpheae Boriss., are characterized by 1-seeded, indehiscent fruits and (usually) glandular foliage. The Amorpheae produce terminal inflorescences and mostly pinnately divided leaves, while the Psoraleeae have inflorescences that technically are axillary and leaves mostly palmately divided (Barneby 1977). Taxonomists have treated the Psoraleeae as consisting of a single diverse and widespread genus, *Psoralea* (e.g., Cronquist 1981), or as composed of a narrowly circumscribed *Psoralea* and several genera segregated from it (e.g. Rydberg 1919–1920). In the most recent monograph covering North American Psoraleeae, Grimes (1990) took the latter approach, following Stirton (1981) in restricting application of *Psoralea* to a few species of the Old World (typified by *P. pinnata* L.) that have solitary flowers in fascicles subtended by lobed cupula, while the inflorescences of the New World segregates are pseudoracemes (racemelike in appearance, but some or many of the nodes with two or more flowers). Grimes apportioned all of the New World Psoraleeae to segregate genera, many of them proposed earlier by Rydberg but not as rigorously defined by him. Grimes' generic reassignments have gained broad acceptance, aided by their prompt adoption by Isely (1990).

The prime characteristic of *Pediomelum*, according to Grimes (1990), is a transverse rupture of the pod (inset, Fig. 4A), the base remaining attached to the receptacle after the beaked distal portion and seed fall away. The genus was divided by Grimes into three subgenera. *Leucocraspedon* Grimes consists of two trailing species of south-central U.S.A. with pinnately-divided leaves, reddish to ochroleucous flowers, and a white ridge surrounding the hilum. The other two subgenera have mostly palmately divided leaves, flowers mostly lavender to bluish-violet, and the hilum not ringed by a white ridge. Subgenus *Disarticulatum* Grimes comprises nine acaulescent or shortly-caulescent species (one composed of two varieties) in which the infructescence disjoints in age at the peduncle-base. Only one species of subgenus *Disarticulatum* occurs east of the Mississippi River (Grimes 1990): *P. subacaule* (Torr. & Gray) Rydb., of calcareous pavement outcrops (cedar glades) of the Interior Low Plateau of Tennessee and Alabama (Nashville Basin and Highland Rim), and more rarely the Ridge and Valley of Alabama (Allison & Stevens 2001) and Georgia (Baskin & Quarterman 1970), the Georgia occurrences about 300 km to the northwest of the Georgia site for *P. piedmontanum*.

The remaining 10 of the 21 *Pediomelum* species accepted by Grimes, with

the addition of *P. piedmontanum*, constitute subgenus *Pediomelum*, with persistent infructescences and a caulescent habit. It is not clear, based on morphology, which of these species is most closely related to *P. piedmontanum*. As the morphological data are supplemented with molecular analyses, evolutionary relationships within *Pediomelum* should become clearer.

Geography and subsessile leaves do not establish a close affinity to the nearly sympatric *Pediomelum canescens*, when weighed against the very different inflorescences of *P. piedmontanum*, many-flowered and persistently congested. The latter are similar, at least in appearance, to those of certain species of western U.S.A., where the subgenus is much more widespread and diversified. The occasional development in *P. piedmontanum* of 4- or 5-foliolate leaves (Fig. 4B) also suggests a closer affinity to some of the western species, as such leaves are unknown in *P. canescens* but typical of such species of the Great Plains as *P. cuspidatum* and *P. esculentum* (Pursh) Rydb. In his monograph, Grimes (1990) opined that there are two natural groups within subgenus *Pediomelum* based on calyx morphology: *P. argophyllum* (Pursh) Grimes, *P. digitatum* (Nutt. ex Torr. & A. Gray) Grimes, *P. canescens*, and *P. aromaticum* (Payson) W.A. Weber appear to be a closely related group of species, with broadly and shallowly campanulate fruiting calices. *Pediomelum piedmontanum*, however, with a narrower, gibbous-campanulate calyx, would fall into the other group from *P. canescens*.

The following modification of Grimes' (1990) *Pediomelum* key to include *P. piedmontanum*, requiring only the expansion of a single couplet, provides a summary of the most conspicuous distinctions from *P. canescens*:

7. Petioles less than 7 mm, or lacking, shorter than the petiolules.
   Inflorescence loose (much of the axis exposed); leaflets 1–3, less than twice as long as wide, petiolules 5–9 mm; of sandy habitats in the Coastal Plain _____ **P. canescens**
   Inflorescence congested (the axis usually concealed); leaflets 3(–5), more than twice as long as wide, petiolules 1.8–3 mm; of rocky habitats in the Piedmont _____ **P. piedmontanum**
7. Petioles longer than 7 mm, or if rarely that short, always equal to or longer than petiolules _____ (*P. cuspidatum* et al.)

Demonstrating major differences from *Pediomelum canescens* does not test the alternative hypothesis that the Piedmont plants constitute a subsessile-leaved variant of a more western species. To rule this out, we compared the Piedmont plants to the descriptions in Ockendon (1965) and Grimes (1990) of all known *Pediomelum* taxa. We found that there are always multiple characters separating the new species from each of its other congeners. For example, *P. piedmontanum* is similar to *P. canescens* in its strongly beaked fruit, small corollas, and subsessile leaves; like only *P. reverchonii* (S. Wats.) Rydb. in its enlarged bracts (causing the Piedmont plants to key to that species in Rydberg 1919–20); and like both *P. cuspidatum* and *P. esculentum* in having many-flowered inflorescences. At the same time, *P. cuspidatum* differs by its much shorter

fruit-beak from both *P. esculentum* and *P. piedmontanum*, while *P. esculentum* has larger corollas, on average, than any of these, besides being uniquely eglandular. In short, our comparison of *P. piedmontanum* with all recognized species of *Pediomelum* indicates that the new taxon is too distinctive to be treated at varietal or subspecific rank, under *P. canescens* or any of the more western species.

Additional research into the systematic relationships, population structure, etc. of *Pediomelum piedmontanum* is underway or is planned for the near future, including, as part of ongoing investigations by Egan of the psoraleoid legumes, a molecular phylogenetic analysis to determine the closest congener for *P. piedmontanum*, and a study of the population genetics of the new species, based on DNA sequences.

HABITAT AND ECOLOGY

The Georgia and South Carolina localities where *Pediomelum piedmontanum* has been found are all located about 20–25 kilometers north of the Fall Line, the name commonly used for the boundary between the Piedmont and Coastal Plain physiographic provinces. At all three of the known occurrences, metamorphic rock is exposed in places, including serpentinite at the Georgia locality (Cocker 1991a, 1991b) and phyllite at the South Carolina sites (Secor & Wagener 1968a, 1968b). Bedrock in these locations appears to be relatively close to the surface over an area of at least a few hectares, extending beyond the actual outcrops. This is inferred from the plant communities, with the openings dominated by drought-tolerant grasses and forbs, such as *Schizachyrium scoparium* (Michx.) Nash and *Hypericum gentianoides* (L.) B.S.P., and the adjacent, thinly-stocked woodlands dominated by drought-tolerant pines and oaks, such as *Pinus echinata* P. Mill., *P. taeda* L., *Quercus falcata* Michx., *Q. stellata* Wangenh., and *Q. marilandica* Muenchh.

Most of the biomass at all sites is composed of fairly widespread species that are frequent in dry, rocky sites of the lower Piedmont. A few relatively infrequent taxa, however, particularly when common to sites in both Georgia and South Carolina, may have some value as indicator species (their occurrences indicating potential habitat for the *Pediomelum*). *Baptisia bracteata* Muhl. ex Ell. and *Vernonia acaulis* (Walt.) Gleason fall into this category. Among species recorded from the Richland County site, the uncommon *Hypericum lloydii* (Svens.) P. Adams may also have some indicator value.

The mix of woody plants and particularly the composition of the herbaceous layer suggest that the soil at these *Pediomelum* sites is somewhat acidic and low in fertility. This was borne out by samples of topsoil, each collected adjacent to a plant of *P. piedmontanum*, that we sent to the University of Georgia Soil Testing Lab for analysis, two from the Georgia locale and one from each of the South Carolina sites. Because of the small number of samples, we refrain

at this time from offering definitive comparisons of soil chemistry among the sites, but all samples had an acidic pH value (4.0–6.2). If the new species were restricted to the Georgia site, as was formerly believed (Allison et al. 2003), its rarity could be easily explained as reflecting adaptation to soil derived from serpentinite, a rock rarely exposed in the eastern United States south of Maryland (Tyndall & Hull 1999). The high levels of magnesium and toxic heavy metals (e.g., chromium and nickel) characteristic of serpentine barrens were reflected in our Georgia test samples, but their concentrations were not nearly as elevated in the samples from the two South Carolina sites. For comparison, we also submitted a soil sample taken from about 9 km southwest of the type locality, from the margin of an outcrop of granite, an abundant rock in the Piedmont. For the pH and the elements named above (Mg, Cr, Ni), as well as for most of the other elements measured, the values returned from the South Carolina samples were more similar to those from the regionally abundant granite outcrop habitat than from the regionally rare serpentinite outcrop of the Georgia type locality. In short, the factors responsible for the apparent extreme rarity of *Pediomelum piedmontanum* are not known at present.

Our observations of the relative vigor of plants indicate that, like the great majority of its associates as well as the other members of subgenus *Pediomelum*, *P. piedmontanum* is a heliophyte. Vigor in the new *Pediomelum* is strongly correlated with the amount of sunlight, with plants growing in the open generally larger and more floriferous than the partly shaded plants growing in the adjacent woodlands. The sizeable, deep-reaching root systems of *P. piedmontanum* and its relatives surely provide both a capacity for underground storage that protect them against drought, while also placing their shoot-meristems mostly out of reach of wildfires, permitting rapid regrowth to take advantage of suddenly reduced competition for light, water, and nutrients. As stated earlier, the famously fire-adapted *Pinus palustris* has persisted at the Georgia type locality, despite fairly effective exclusion of fire at the site for decades. It seems likely that at the South Carolina sites there are (or were at one time) natural openings, long-persistent due to shallowness and infertility of soil, that were prevented in the past from total closure by occasional fires. It is apparent that the controlled use of fire should be a primary management tool for the protection and enhancement of populations of *Pediomelum piedmontanum*.

In terms of pollination ecology, papilionoid flowers like those of *Pediomelum piedmontanum* are considered the product of natural selection reflecting entomophily. A detailed study of pollinators has not been undertaken, but Morris observed various insects visiting the flowers on June 2, 2002, including bees (probable *Bombus* spp.) and several species of butterflies, including the pipevine swallowtail (*Battus philenor*), eastern tailed blue (*Everes comyntas*), buckeye butterfly (*Junonia coenia*), and dusky winged skippers

(*Erynnis* spp.). The larvae of two of these (*Everes comyntas*, *Erynnis* spp.) have been recorded as feeding upon one or more legume genera (Klots 1951).

CONSERVATION STATUS

Pediomelum piedmontanum appears to be a very rare species. It is difficult to imagine that such a striking and distinctive plant, relatively large among the herbaceous legumes of its region, could be merely uncommon and yet be represented in herbaria by so few specimens. Indeed, publication has been delayed until now in part by our concern that the outcome might include its extirpation by collectors. That concern has been only slightly reduced by the increase in the number of known sites to three, from the single one known at the time of Allison et al. (2003).

According to NatureServe's global conservation status ranking, a system very similar to the IUCN Redlist criteria, *Pediomelum piedmontanum* would be classified as Critically Imperiled (Global Rarity Rank = G1), a rank that should be qualified with a question mark (G1?), indicating that the taxon is not well known enough to assign a rarity rank with confidence. The chief source of doubt is the fact that Egan found the Lexington County population quite serendipitously, offering hope that there are at least a few other populations awaiting discovery. We plan to search for such populations, especially in South Carolina. We will also seek partnerships with landowners, land managers, and conservation agencies/NGOs to protect and enhance the known localities.

As there is no guarantee that protection of any of the sites will be possible, we have taken the precaution of twice collecting seeds from the type locality and providing them to the Atlanta Botanical Garden. The first batch of seeds has already yielded a few plants. We intend to work with the ABG and others to use these and future production to establish one or more experimental populations, in locations near the type locality and with similar edaphic characteristics. We do not consider that such efforts can be assumed to be sufficient to guarantee the long term survival of *Pediomelum piedmontanum*, however, and we urge an expedited consideration of its listing under the federal Endangered Species Act and corresponding state laws.

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of Classics, University of Georgia, for improvements to the Latin diagnosis. Allison and Morris are thankful to Thomas S. Patrick of the GNHP for sharing his recollections, specimens, and advice, and for companionship in the field. Morris is also grateful to the U.S. Fish and Wildlife Service and the GaDNR for funding of the *Scutellaria ocmulgee* survey during which he first encountered the future *Pediomelum piedmontanum*. He also thanks the Georgia Native Plant Society for providing a grant to NGCSU to support an ongoing floristic study of the type locality and environs, and he appreciates the dedication and interest of undergraduates and faculty in the Department of Biology at NGCSU who are involved in these and other studies related to the new species. Egan thanks John Nelson of USCH for alerting her to the problematic Angerman collection, and for a loan that included it and material of *P. canescens*, very useful for comparison with the new species, and to the curators of AUA, FLAS, FSU, FTBG, GEO, MISS, NCU, TROY, USCH, USF, VSC, and WFU for providing *P. canescens* locality data. She would also like to thank her advisor, Keith A. Crandall, for helping fund her fieldwork, as well as the Society for Systematic Biology and the American Society of Plant Taxonomy for support in the form of graduate student fellowships. Egan is also grateful to her mother, LaDean Egan, for her steadfast assistance and companionship in the field. Finally, all three authors wish to thank two reviewers for suggesting valuable improvements to the manuscript, Richard LeBlond of the North Carolina Natural Heritage Program, and Gregory T. Chandler of the University of North Carolina at Wilmington.

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Book Review

Petr Sklenář, James L.Luteyn, Carmen Ulloa Ulloa, Peter J. Jørgensen, and Michael O. Dillon. 2005. **Flora Genérica de los Páramos: Guía Illustrada de las Plantas Vascalares.** (ISSN 0077-8931; ISBN 089527-468-2). Memoirs of the New York Botanical Garden, volume 92. New York Botanical Garden Press, 200th Street & Kazimiroff Blvd., Bronx, New York, 10458-5126, U.S.A. (**Orders:** nybgpress@nybg.org). $85.00, 499 pp., 6 1/2" × 9 1/2".

The term páramos is often misunderstood even in some biological contexts. In this book's introduction, the authors rectify the misconceptions and clarify the word. Páramos is not an area confined to northern South American but rather it is an ecosystem that extends from the higher mountains of Costa Rica and Panama to northern Peru, thus embracing these countries as well as Colombia, Ecuador, and Venezuela. It is an ecosystem rich in biodiversity and endemism and one of ecological extremes, to which the flora has adapted. Plant characteristics include acaulescent rosettes, shrubs with minute leaves, prostrate dwarf shrubs, and geophytes. The purpose of the book, however, is not to introduce these plants but to serve students and professionals as a guide to the genera of vascular plants, ultimately as an incentive for the protection of this unique and valuable ecosystem.

With this objective in mind, the authors provide many keys: a basic one to each of the major groups from pteridophytes to flowering plants, with especial attention to leaf structures, which account for five of the eight general keys. Within each of the 112 families (alphabetically listed) are keys to the 540 genera and keys to tribes. The text fully describes the genus and notes the countries and altitudes at which the plants grow. Accompanying the text is a picture, in most cases a drawing, of the single species in the genus or a representative species; almost all of these were previously published and are so acknowledged in an appendix. References follow each entry.

The five authors are at major botanical institutions. The leading author, Petr Sklenář is associated with the New York Botanical Garden and teaches at Charles University, Prague. Nine other professionals are cited as contributors.—*Joann Karges (retired TCU Library), Botanical Research Institute of Texas, Fort Worth, TX 76102-4060, U.S.A.*

Editor's note.—See page 724.

BIG-FRUITED BUCKTHORN, *SIDEROXYLON MACROCARPUM* (SAPOTACEAE), A LONG-FORGOTTEN GEORGIA ENDEMIC

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ABSTRACT

Bumelia macrocarpa Nutt. languished in obscurity for more than 150 years. Thomas Nuttall (1786–1859) collected this low shrub in 1830 and described it in 1849. Asa Gray relegated it to the synonymy of *B. lanuginosa* (Michx.) Pers. in 1886, apparently due to the lack of subsequent collections and without seeing any material of Nuttall's plant. In 1940 Robert Clark identified type material of *B. macrocarpa* as *B. reclinata* (Michx.) Vent., failing to notice the fact that more than one species had been mounted on the sheet, with only one small fragment actually representing *B. macrocarpa*. Since *Bumelia* Swartz is now considered to be a synonym of *Sideroxylon* L., the restoration of this distinctive species, endemic to southeastern Georgia (U.S.A.), requires a new combination, *S. macrocarpum* (Nutt.) J.R. Allison.

RESUMEN

Bumelia macrocarpa Nutt. languideció en la oscuridad durante más de 150 años. Thomas Nuttall (1786-1859) coleccionó este arbusto bajo en 1830 y lo describió en 1849. Asa Gray lo relegó a la sinonimia de *B. lanuginosa* (Michx.) Pers. en 1886, aparentemente debido a la carencia de colecciones subsiguientes y sin ver ningún material de la planta de Nuttall. En 1940 Robert Clark identificó el material tipo de *B. macrocarpa* como *B. reclinata* (Michx.) Vent., al no notar el hecho que se había montado en la lámina más de una especie, con un solo fragmento pequeño que representa en realidad *B. macrocarpa*. Puesto que *Bumelia* Swartz se considera actualmente un sinónimo de *Sideroxylon* L., la restauración de esta especie distintiva, endémica al sureste de Georgia (EEUU), requiere una nueva combinación, *S. macrocarpum* (Nutt.) J.R. Allison.

INTRODUCTION

Among the genera of woody plants listed in the work that launched the modern system of binomial nomenclature, Linnaeus' *Species Plantarum* of 1753,[1] was *Sideroxylon* L. (<Gk. *sideros*, iron + *xylon*, wood). In the second edition, of 1762, he named the first *Sideroxylon* from the southeastern United States, *S. lycioides* L., and in 1767 a second one, *S. tenax* L. The species of the temperate southeastern U.S.A. (one species extending sparingly to Arizona), spiny shrubs or small trees with short styles and finely reticulate, often fascicled leaves, were usually treated under the genus *Bumelia* Swartz for two centuries following the latter's segregation from *Sideroxylon* in 1788 (e.g. de Candolle 1844; Gray 1886; Small 1933; Wood & Channell 1960; Godfrey 1988). An early exception was

[1]For more nomenclatural citations, see Pennington 1990.

Michaux's (posthumous) description of two species from Georgia in 1803, *S. lanuginosum* Michx. and *S. reclinatum* Michx. In the following pages, I use one or the other generic name interchangeably as deemed appropriate, mostly using *Bumelia* when referring to works which used it, *Sideroxylon* when discussing more recent treatments or concepts. Whatever the botanical name, "buckthorn" has been in use as a vernacular name for these plants for many years (Gray 1878).

All four of these species were restored to their original nomenclature when T.D. Pennington (1990, 1991) synonymized *Bumelia* under *Sideroxylon* as not constituting a natural (monophyletic) group. For his coverage of the hardy taxa of the southeastern U.S.A., Pennington (1990) was explicit that he relied almost exclusively on Arthur Cronquist's (1945, 1949) publications on *Bumelia*. Although at least two dozen species had been named from the U.S. in the 150 years after Michaux, Cronquist (1945) opined that "not a single valid species of *Bumelia* seems to have been described from the United States since the appearance of Michaux's flora in 1803." Four years after this remark, however, Cronquist (1949) described *B. thornei* Cronq., from collections he had seen from southwestern Georgia. Relying on Cronquist's conservative treatment simplified Pennington's (1990) task, as this meant only five temperate species of *Sideroxylon* to be treated, the two each of Linnaeus and Michaux, and *S. thornei* (Cronq.) Pennington.[2]

However, another monograph covering these species (except *Sideroxylon thornei*), by Robert Clark (1942), had been published just three years before Cronquist's. I consider these almost polar opposites, Cronquist's a "lumper's" treatment and Clark's that of a "splitter." For Pennington to have weighed the validity of all the taxa recognized by Clark was clearly beyond the intended scope of Pennington's work, which was focused on the Neotropical members of *Sideroxylon* and other genera of Sapotaceae.

In Clark's revision of the U.S. species of *Bumelia*, he recognized 14 species as well as 2 varieties each of *B. lanuginosa* (Michx.) Pers. and *B. lycioides* (L.) Pers., not including their type varieties. He accepted *B. texana* Buckl. and *B. rufa* Raf., raised *B. lanuginosa* var. *anomala* Sarg. and var. *rigida* A. Gray to species rank, and accepted most of the species named by J.K. Small. Despite Clark's splitter's perspective, he did, without comment, reduce to synonymy under *B. reclinata* (Michx.) Vent. one taxon that had been accepted by Asa Gray in the

[2]A more distantly related, non-hardy "*Bumelia*" of the Caribbean has long been known from the warmer areas of the southeastern U.S.A., in southern Texas and peninsular Florida. It has been treated under several names, e.g. *B. cuneata* Swartz (misapplied by Gray), *B. angustifolia* Nutt. (nom. superfl., published 24 years after the next), *B. celastrina* Kunth, and now *Sideroxylon celastrinum* (Kunth) T.D. Pennington. The still more distantly related *S. salicifolium* (L.) Lam. and *S. foetidissimum* Jacq. are also known from peninsular Florida; they were treated by Cronquist (1945, 1946) as *Dipholis salicifolia* (L.) A. DC. and *Mastichodendron foetidissimum* (Jacq.) Lam., respectively.

first edition of the *Synoptical Flora* (1878): *B. lanuginosa* var. *macrocarpa* (Nutt.) A. Gray. Clark's decision was no doubt based on his examination of the only specimen (Fig. 1) known to exist, at least in North America, that was identified as *B. lanuginosa* var. *macrocarpa* or as its basionym, *B. macrocarpa* Nutt. The specimen shows no sign of having been examined by Cronquist, who, like Clark, listed *B. macrocarpa* in the synonymy of *B. reclinata*.

I have concluded that Clark's annotation of the sheet in question as *Bumelia reclinata* resulted from an insufficiently thorough examination of it. The sheet is in fact a mixture, bearing four fragments correctly identified by Clark as the glabrate *B. reclinata*, and a single fragment with smaller, thinly but persistently strigose leaves corresponding to the protologue (Nuttall 1849) of *B. macrocarpa*. This fragment also matches plants known today from the same region and sandy, upland habitat indicated in Nuttall's protologue.

In this paper I restore this taxon, a Georgia endemic (Fig. 2), to species status. Although the specific epithet *macrocarpa* has been used within other Sapotaceous genera, it does not appear to be preoccupied in *Sideroxylon*. Therefore the plant's transfer to *Sideroxylon* requires only a new combination. As this taxon has never received a detailed description, I provide one, constructed to parallel those in Pennington 1990.

TAXONOMIC TREATMENT AND DESCRIPTION

Sideroxylon macrocarpum (Nutt.) J.R. Allison, comb. nov. (**Figs. 3–5**). BASIONYM: *Bumelia macrocarpa* Nutt. Sylva 3:34. 1849. *Bumelia lanuginosa* var. *macrocarpa* A. Gray. Syn. Fl. 2(1): 68. 1878. TYPE: U.S.A. GEORGIA (according to the protologue, "sandy hills not far from the Altamaha"): *Nuttall s.n.* (LECTOTYPE [Fig. 1]: PH, accession no. 1030290, the small fragment at top left *only*, which pierces Nuttall's original label).

Plants soboliferous shrubs less than 1 m high, usually under 0.5 m; geoxylic (woody underground) stems much longer than the aerial, to at least 10 mm thick; aerial (leafy) stems 0.5–2(–3) mm thick, often with thornlike branchlets bearing reduced leaves. Long shoots (elongation or leader) tan or reddish-brown and tomentulose when young, the hairs blondish or some of them ferruginous, soon glabrate, gray with age, armed at most nodes with slender, slightly curved, sharp thorns (2–)2.5–13(–20) mm long; some thorns becoming short spur-shoots. **Leaves** tardily deciduous, coriaceous, spirally alternate and spaced at first, soon becoming fascicled on short shoots, internodes (1–)2–12(–21) mm long (imperceptible on short [spur-] shoots); petioles (0.5–)1–3(–5) mm long, channeled, pilosulous; blades dark green above, paler beneath, narrowly oblanceolate to obovate or spatulate, or broadly elliptic to suborbicular, especially on some spur-shoots, (0.3–)1–4(–5.2) cm long, (0.2–)0.4–1.5(–2.1) cm wide, glabrate above, persistently and rather sparsely strigose beneath, occasionally virtually glabrate, the hairs blond or rarely slightly rufous; apex obtuse or rounded, sometimes retuse, base cuneate or acute; venation brochiodromous or eucamptodromous,



FIG. 1. The only specimen found at PH of *Bumelia macrocarpa*, labeled as *Bumelia lanuginosa* var. *macrocarpa*. Inset, placed over a large blank space on the sheet: the only material of genuine *B. macrocarpa* (=*Sideroxylon macrocarpum*) on the sheet, bearing three persistent, puberulent leaves of the previous season, and several densely hairy leaves just beginning to expand. The four other fragments are *S. reclinatum* s. str.

without a marginal vein, midrib flat or slightly sunken on the upper surface, secondary veins mostly 5–8 pairs, ascending, arcuate, intersecondaries usually moderately long; tertiaries reticulate-areolate on both surfaces. **Flowers** bisexual, actinomorphic, in axillary (1–)2–15(–18)-flowered fascicles on growth of the preceding year. Pedicels 1–3(–5.5) mm long, pubescent. Sepals (4–)5(–6), unequal (outer pair slightly shorter) (2.1–)2.5–3 mm long, suborbicular to ovate, sparsely to moderately pale sericeous-tomentulose, margins scarious, apex rounded to subtruncate or slightly retuse. Corolla (4)5(6)-merous, creamy white; tube (0.7–)

1–1.3 mm long, lobes (1.8–)2.4–3(–3.5) mm long, erose; medial lobe-segment erect in anthesis, ovate to suborbicular, apex rounded, lateral segments (appendages) infolded in anthesis, obtuse or sometimes acute, (1.5–)1.8–2.3(–3.1) mm long, lanceolate to nearly oblong. Stamens (4–)5(–6), filaments 1–2 mm long, anthers 1.1–1.3(–1.5) mm long, lanceolate. Staminodes (4–)5(–6), infolded, (1.2–)1.3–1.8(–2.0) mm long, reaching (1/3) 1/2–2/3 the length of the corolla midlobes and exceeded by the lateral lobes, lanceolate to ovate, apex acute to rounded. Ovary broadly ellipsoid, glabrous or medially villosulous. Style 1.0–1.3(–1.5) mm long after anthesis, glabrous; style-head simple. **Fruit** smooth, black, somewhat lustrous, ellipsoid to subglobose, often tipped by the persistent style-base, when fresh 9–12(–14) mm long, 8.5–10 mm wide, apex and base rounded, pericarp ca. 2 mm thick, fleshy, sweet. Seed solitary, (7.3–)8–9 mm long, 5.5–7 mm wide, ellipsoid or obovoid, with truncate base. Testa hard, smooth, evenly brown, moderately lustrous, 0.5–1 mm thick; scar basal, in two parts, a roughly semicircular area 2–3 mm across and a smaller, deltate to lunate abaxial area, the two sometimes joining.

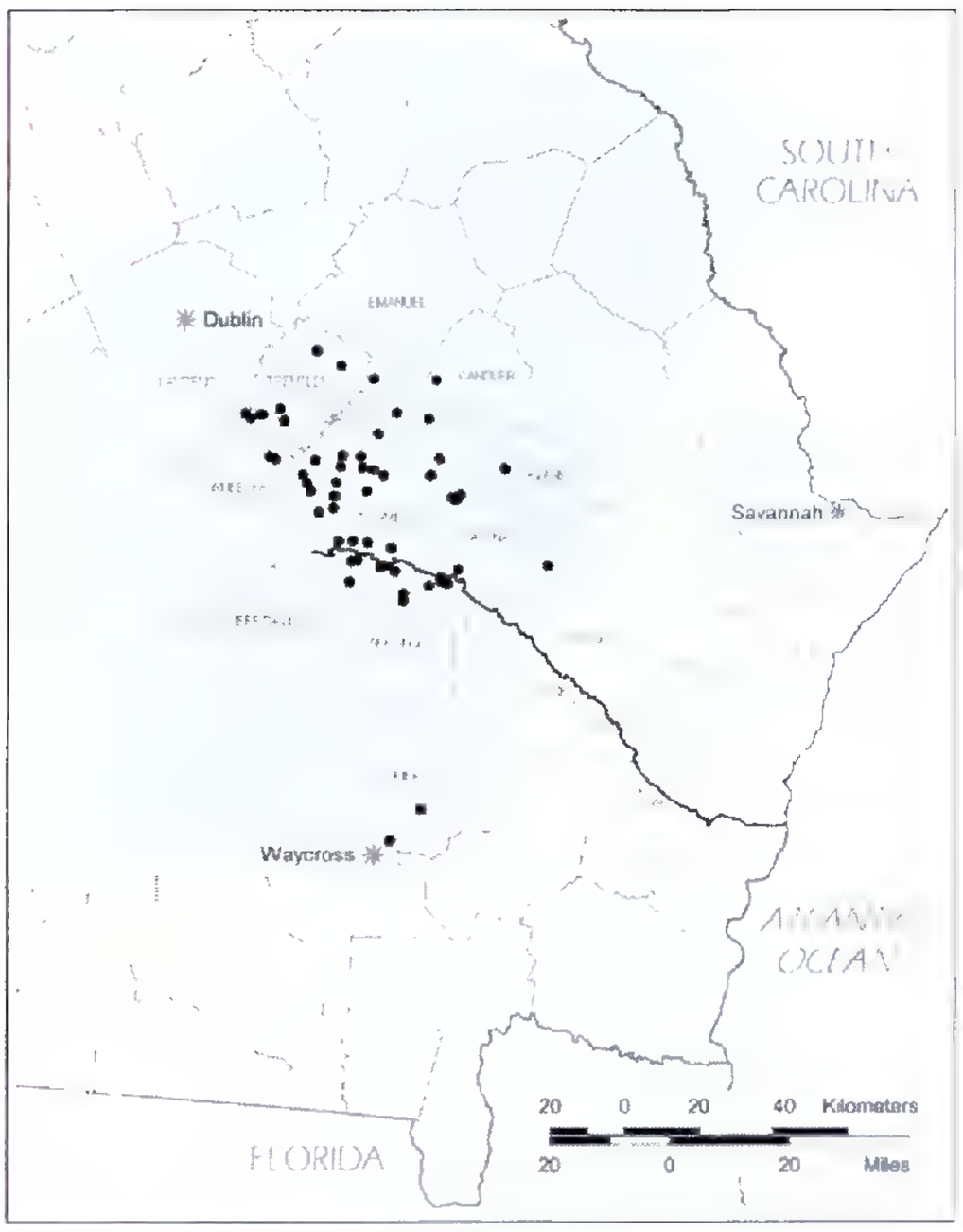


FIG. 2. County outline map of southeastern Georgia showing known localities of *Sideroxylon macrocarpum* (dots), the Altamaha River, and three cities. The shaded area corresponds to the approximate eastern extent of the Altamaha Formation, as mapped in Huddlestun 1988.

Phenology and habitat.—Flowering late May through June, or sporadically through September. Sandy, well-drained, partly open, pine-oak woodlands and pine-oak scrub, southeastern Georgia, U.S.A.

Additional collections examined: **UNITED STATES. GEORGIA: Appling Co.:** Co. Rd. 537, 20 Sep 1993, *Nordman & Tassin s.n.* (GA); Co. Rd. 368, 20 Sep 1993, *Nordman & Tassin s.n.* (GH); Co. Rd. 363, 20 Sep 1993, *Nordman & Tassin s.n.* (NY); 25 Jul 1996, *Allison & Tassin 9352* (FSU, NCU); just SE of Hatch nuclear power plant, 26 May 1999, *Nelson & Kennemore 20559* (USCH). **Candler Co.:** GA 46, 27 Sep 1994, *Allison 8606* (USCH); 29 May 1996, *Allison 9203* (FSU, GA); 10 Sep 2005, *Allison 13782* (CLEMS, VSC). **Emanuel Co.:** 25 mi S of Swainsboro, 24 Apr 1937, *Henry 1019* (NY); GA 46, 29 May 1996, *Allison 9200* (JSU); US 1, 10 Jul 1995, *Allison 8914* (FLAS, UNA, USCH); 29 May 1996, *Allison 9202* (FSU); 16 Jun 1999, *Allison 12022* (GA, GH, MICH, TAMU, TENN, TROY). **Evans Co.:** 1.8 mi NW of Bellville, 7 Apr 1997, *Van de Genachte et al. s.n.* (PH); 16 Sep 2001, *Allison 13043* (GA, GH, NCU, NY, US); 11 Sep 2005, *Allison 13796* (GA, VDB); 1.6 mi NW of Bellville, *Allison 9764* (FSU, MO, USCH). **Jeff Davis Co.:** Bullard Creek WMA, 8 May 1997, *Allison 9768* (FSU); 8 Jun 1999, *Allison 11988* (AUA, BRIT, CLEMS, FLAS, GA, GH, JSU, MICH, MO, NCU, NY, PH, TAMU, TENN, TEX, TROY, UNA, US, VDB, VSC); 29 Sep 1999, *Allison 12220* (GA); near Perry Miller Rd., immediately W of Appling Co. line, 26 May 1999,

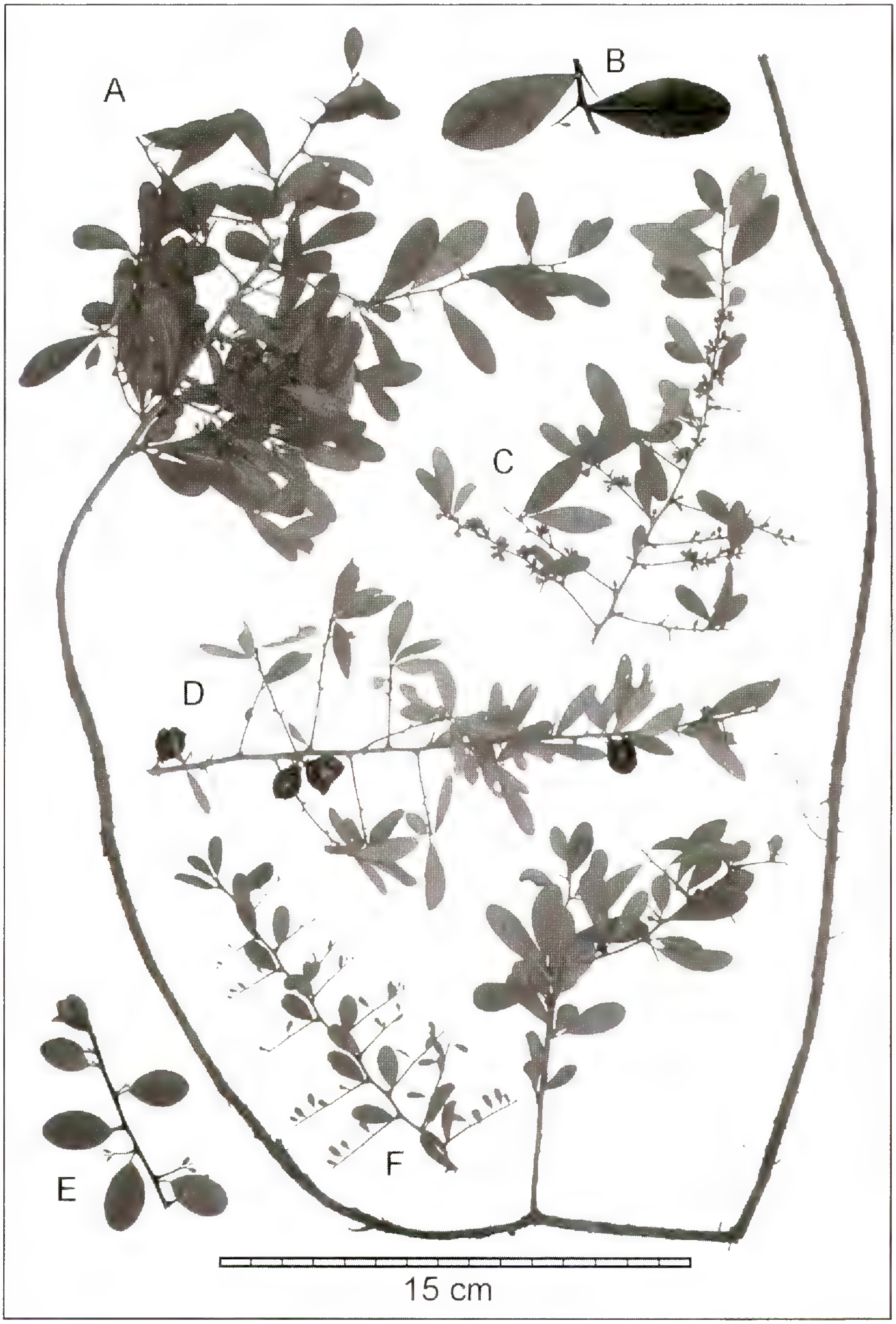


Fig. 3. *Sideroxylon macrocarpum* specimen-collage, from collections at GA, all to same scale. **A.** Two (leafy) aerial shoots arising from one (incomplete) sparsely-rooted geoxylic stem, *Allison 11988*. **B.** Part of stem with larger than normal leaves (to 5 × 2.1 cm), *Allison 8607*. **C.** Flowering stem, *Allison 12040*. **D.** Stem fragment bearing mature fruits, *Allison 13048*. **E.** Stem fragment with a leaf shape more typical of *S. rufohirtum*, *Allison 13043*. **F.** Stem with thornlike branchlets bearing reduced leaves, *Allison 12022*.

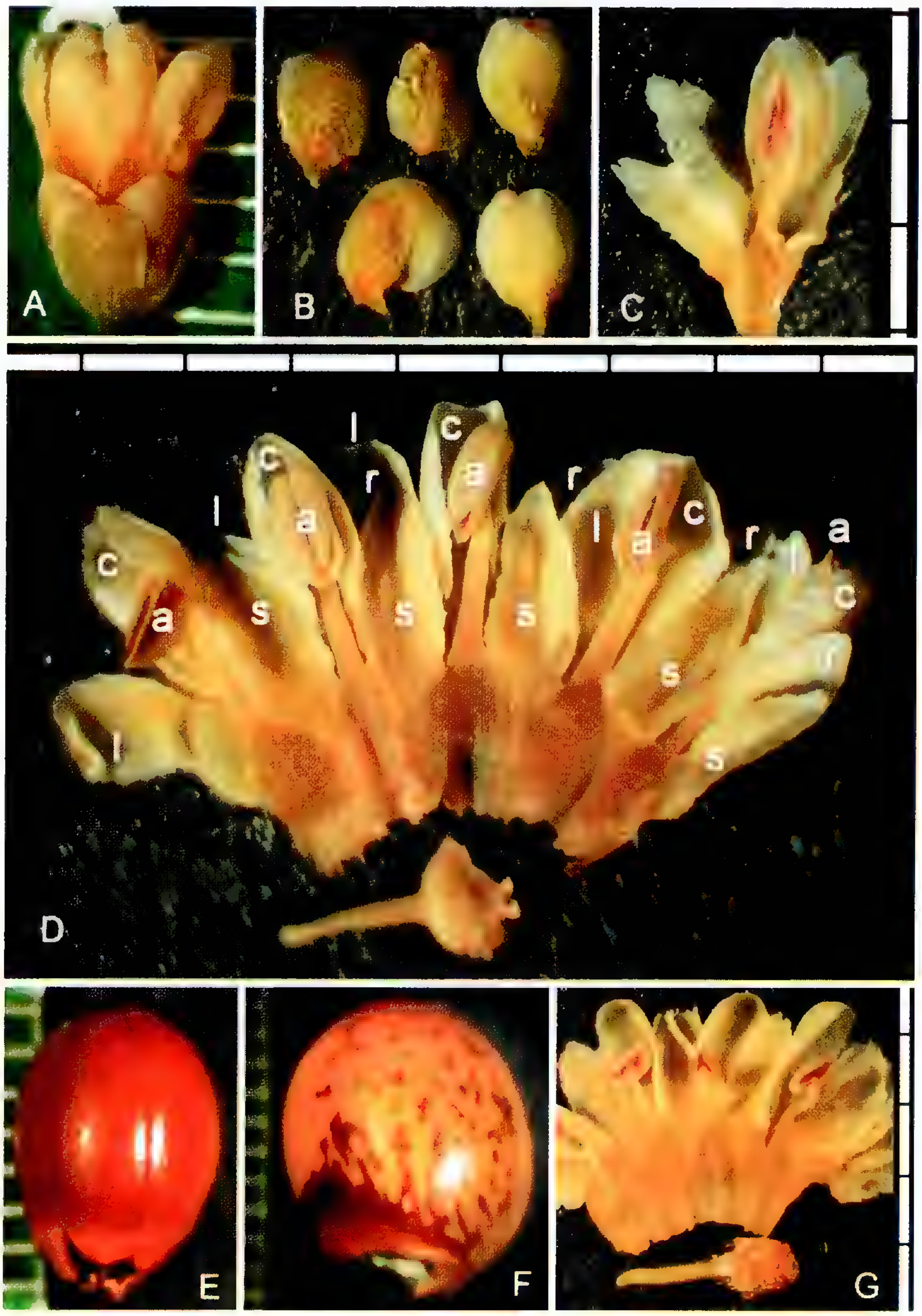


FIG. 4. *Sideroxylon* sample dissections and seeds, from collections at GA (against millimeter rulers or with bars marked in millimeters). **A–D,** from rehydrated flowers of *S. macrocarpum* (*Allison 9203*). **A.** Flower. On the right side of the corolla the tripartite division of a corolla-lobe is evident. **B.** Sepals, the outer two greener and slightly smaller (same scale as A). **C.** Part of a flower; from left to right: a staminode, a left corolla-lobe appendage, a corolla-lobe and stamen, and a right corolla-lobe appendage. **D.** Above, spread corolla and androecium: a = anther, s = staminode, c = corolla-lobe, l or r = left/right appendage of corolla-lobe (one of the latter completely obscured by a corolla-lobe). Below, upper portion of pistil: style and (glabrous) summit of ovary. **E.** Seed of *S. macrocarpum* (*Allison 13048*). **F & G,** comparative material of *S. rufohirtum*: **F.** Variegated seed (*Allison 12292*). **G.** Floral dissection: the proportionately larger staminodes mostly obscuring the corolla-lobe appendages (apex of one is visible at 11 o'clock), and the ovary rufous-hairy (*Allison & Anderson 9918*).

Nelson & Kennemore 20576 (USCH). **Laurens Co.:** GA 19, 21 Aug 1996, *Allison 9404* (AUA, BRIT, FSU, US, USCH); 18 Jun 1999, *Allison 12040* (GA, MO). **Long Co.:** Ft. Stewart, N of GA 144, near Tattnall Co., 25 Aug 1992, *Zebryk et al. 598* (GA); 8 May 1997, *Allison 9766* (USCH, VSC); 9 Jun 1997, *Allison 9876* (FSU, GA, NY). **Montgomery Co.:** Co. Rd. 171, 21 Aug 1996, *Allison 9408* (USCH); US 280, 21 Aug 1996, *Allison 9409* (FSU, TEX); GA 135, S of Alston, 22 Aug 1996, *Allison 9411* (GA); GA 135, 3 1/2 mi N of Alston, 7 May 1997, *Allison 9746* (CLEMS, JSU, PH). **Pierce Co.:** N of Satilla R., near US 82, 6 Jul 1959, *Cypert 211* (GA); 2 mi N of Blackshear, 9 Nov 1994, *Allison 8754* (FSU); 29 Sep 1999, *Allison 12228* (FLAS, GA, TENN, USCH). **Tattnall Co.:** near Reidsville, 24 Jun 1903, *Harper 1851* (GH, 2 sheets; MO; NY); NW of Reidsville, 27 May 1957, *Broughton s.n.* (GA); E of Ohoopee R., near GA 292, 29 Aug 1985, *Rayner & McCartney 2401* (USCH); May 1987, *McCartney s.n.* (GA); Gordonia Alatamaha State Park, 20 Sep 1993, *Nordman et al. s.n.* (US); GA 57/121 near N limits of Reidsville, 17 Oct 1993, *Nordman et al. s.n.* (MICH); 27 Sep 1994, *Allison 8607* (GA); 30 May 1996, *Allison 9207* (FLAS, FSU, TAMU, TROY) **Toombs Co.:** 3.8 mi N40°W of Lyons, 24 Oct 1952, *Duncan & Hardin 14622* (GA); Co. Rd. 364 at Co. Rd. 279, 25 Aug 1993, *Nordman s.n.* (BRIT); 0.2 mi SW of Old Smyrna Cem., 25 Aug 1993, *Nordman & Tassin s.n.* (MO); GA 86 near Pendleton Creek, 17 Sep 1993, *Nordman et al.* (PH); U.S. 280, 12 Sep 1995, *Allison 8978* (USCH, VSC); GA 15, 22 Aug 1996, *Allison 9418* (GA). **Treutlen Co.:** Co. Rd. 167, 5 Oct 1994, *Allison 8662* (BRIT, JSU, MO, NCU, NY); 29 May 1996, *Allison 9199* (FSU, GA, VDB); GA 86, 23 Aug 1996, *Allison 9430* (USCH). **Wheeler Co.:** GA 46, 4 Jul 1996, *Snow s.n.* (GA); 26 Jul 1996, *Allison & Snow 9356* (GA); GA 19, 21 Aug 1996, *Allison 9406* (AUA, FSU, TEX, US, USCH); 17 Sep 2001, *Allison 13048* (GA, MICH, UNA).

HISTORY OF TAXON

Nuttall's choice of epithet, *macrocarpa*, "large-fruited," was surely intended to contrast with the small fruit of the only other relatively low and small-leaved species known to him from the U.S.A., *Bumelia reclinata*. His treatment of what I call *Sideroxylon macrocarpum* is a fairly accurate, if incomplete, description of the plant known today from many more observations, made throughout the growing season. The protologue is brief enough to be quoted here in its entirety:

> LARGE-FRUITED BUMELIA.
>
> BUMELIA MACROCARPA, depressa, ramis gracilibus valde spinosis, spinis elongatis tenuibus subrecurvis, foliis parvulis cuneato-lanceolatis obtusis junioribus lanuginosis, demum subglabris concoloribus; drupa maxime ovali.
>
> This very low bushy species, allied to *B. reclinata*, I give (though from very imperfect specimens) to complete the history of our species of the genus. The twigs are very slender, at first pubescent, covered with a grey bark, and with the spines long and slender as needles. The leaves, before expansion, are exceedingly lanuginous, and always small, with very short petioles, at length nearly smooth. The fruit is edible, and as large as a small date! I found this species on the sandy hills not far from the Altamaha, in Georgia, in winter, and therefore do not know the flower. It does not grow more than a foot high, and the leaves are little more than half an inch long.

Nuttall's collection was probably made in 1830. According to Graustein (1967), it is only in that year that Nuttall visited the area of Georgia where the plant is known to grow today. She also indicates that he was in the Florida Pan-



Fig. 5. *Sideroxylon macrocarpum* in life. Above: unusually extensive patch (10 m^2 or more); source of *Allison 9764*, in sandy powerline right-of-way, Evans Co., 8 May 1997; note young *Pinus palustris*, top center. Below, same locality and date: sandy, well-drained habitat, with gopher tortoise burrow (just left of center) and a small clump of *S. macrocarpum* (indicated by arrow). Inset: branch with leaves, thorns, and a mature fruit, prior to collection as part of *Allison 12228*, Pierce Co., 29 Sep 1999.

handle early in March of 1830, subsequently crossed the Altamaha River[!] en route to Savannah, where he departed the Southeast by ship, and that he was back in Pennsylvania by April 17. As Nuttall indicated that he had seen the buckthorn only in winter, it is likely that the collection was made in mid-March.

When Gray (1878) reduced *Bumelia macrocarpa* to *B. lanuginosa* var. *macrocarpa*, not quite three decades after Nuttall described it, he added, "To be rediscovered." Presumably the lack of subsequent collections was a major factor when Gray later (1886) dropped his variety *macrocarpa*, listing *B. macrocarpa* in the synonymy of *B. lanuginosa* and stating that Nuttall's plant "must be this or the preceding" [*B. tenax* (L.) Willd.]. Seemingly, Gray came to regard Nuttall's plant as likely to have been merely an aberrant form of a previously described species, and eliminated *B. reclinata* from consideration due to the latter's small fruit and typically glabrate leaves.

A second collection of *Sideroxylon macrocarpum* would not be made until the early years of the 20th Century, when the region of Georgia to which Nuttall's plant is endemic was explored botanically by Roland M. Harper for his doctoral dissertation, published as *A Phytogeographical Sketch of the Altamaha Grit Region of the Coastal Plain of Georgia* (Harper 1906). "Altamaha Grit" refers to a stratigraphic unit now called the Altamaha Formation (Huddleston 1988). Harper cited *Harper 1851* under *Bumelia reclinata*, and listed additional sites from sandhills or dry pine barrens in Tattnall, Montgomery, and (present day) Wheeler Counties. The latter were presumably sight records, as no specimens were cited. Given their geographic location and habitat, Harper's three sight records of "*B. reclinata*" almost certainly also represent *S. macrocarpum*. Another collection is known from the first half of the 20th century, *Mrs. J.N. Henry 1019* (NY), from 1937. Its label bears no determination except for the word *Bumelia*, handwritten anonymously just above the label, and was otherwise never annotated.

The next three collections of *Sideroxylon macrocarpum* known to me are at GA: *Duncan & Hardin 14622* (in 1952, Toombs County), *Broughton s.n.* (1957, Tattnall Co.), and *Cypert 211* (1959, Pierce Co.). Wilbur Duncan identified his and Broughton's specimens as *Bumelia reclinata*, Cypert's as *B. lanuginosa*. These specimens were annotated by Cronquist in 1970, two of them simply as "*Bumelia thornei* Cronq." Cronquist elaborated slightly in his annotation of *Duncan & Hardin 14622*: "An unusual specimen which may perhaps best be associated with *B. thornei*." The habitat information supplied on the labels indicated that all three collections came from dry, sandy habitats. That they came from such habitats presumably posed no problem for Cronquist, since in naming *B. thornei* he had (erroneously) cited the habitat of the type (*Thorne 7345*, GA) as "*dry* [my emphasis, here and in the next quotation] live oak woods by cypress swamp" (Cronquist 1949). However, this conflicts with the habitat given by Robert Thorne himself (1949) for the type locality, namely "*moist* live oak woods at

edge of cypress swamp." Furthermore, Thorne (1949, 1954) gave the habitat of the species as a whole as "sandy, moist, open meadows or woods." Cronquist's mis-annotations of 1970 would have significant consequences.

The paucity of occurrences known for *Bumelia thornei* was undoubtedly the primary reason for its listing, in August 1977, as an endangered species under provisions of the Georgia Wildflower Preservation Act (Patrick et al. 1995). A month later McCollum and Ettman (1977) published a treatment of all the species then protected under that statute, with a description, Georgia range map, and line drawing of each. This government publication was made available free of charge and had wide distribution within the state. In it *B. thornei* was characterized as "a small, thorny shrub up to 1.5 m tall," that was found "in dry, live oak woods and scrub oak sandhills." Clearly their concept of *B. thornei* derived from Cronquist's original, somewhat faulty description and from at least one of his 1970 annotations, of *Broughton s.n.*, whose label gave the habitat as "scrub oak sandhills."

For more than ten years following McCollum and Ettman 1977, *Bumelia thornei* was considered by most botanists in the Southeast to be a low shrub of dry habitats. For example, in 1985 Robert B. McCartney reported to the Georgia Department of Natural Resources (GaDNR) his finding of a "new *Bumelia thornei* location," in Tattnall County (correspondence in files of the Natural Heritage Program of the GaDNR). In March of 1987 McCartney led a small group of botanists, myself included, to this population, which corresponded perfectly in habit and habitat to the treatment of *B. thornei* in McCollum and Ettman 1977. At this point Nuttall's *B. macrocarpa* had been languishing in synonymy for just over a century and completely forgotten by Georgia botanists.

Not surprisingly, knowledge gained in the decades subsequent to Clark 1942 and Cronquist 1945 supports a taxonomy of this group of species somewhere between the extremes represented by those two workers. To be fair to Cronquist, he was frank that the firmness of his taxonomic judgments was proportionate to the number of herbarium specimens available to him. The taxa named post-Michaux were usually represented by few collections. For some of these, rather more material has of course proved helpful, especially when combined with significant field experience with the plants, which neither Clark nor Cronquist could claim.

In contrast, Robert Godfrey had considerable experience with the group as *living* plants. For example, he is credited with the earliest known collection of *Sideroxylon thornei* from Florida, made in 1982 (Anderson 1988). Informed by his field experience with two taxa that had been treated by Cronquist (1945) as *Bumelia reclinata* var. *rufotomentosa* (Small) Cronq. and *B. tenax* f. *anomala* (Sarg.) Cronq., Godfrey (1988) restored them to species rank, as *B. rufotomentosa* Small and *B. anomala* (Sarg.) Clark. In this work Godfrey added new precision to their descriptions and discussed them in some detail, with line drawings of

each by Melanie Darst. Both of these buckthorns, however, had specific epithets that were preoccupied in *Sideroxylon*, so their eventual transfer to that genus at the rank of species required new names: *S. rufohirtum* Herring and Judd (1995) for *B. rufotomentosa*, and *S. alachuense* L.C. Anders. (Anderson 1997) for *B. anomala*.

In the same work, Godfrey revised the description of *Bumelia thornei*, giving the normal height (accurately) as around 2 1/2 meters, with a maximum plant height of 6 meters. He also described its fruits as larger than those of *B. lanuginosa*, whereas Cronquist (1949) in the *B. thornei* protologue had erroneously stated precisely the opposite.[3] Godfrey also correctly made *B. thornei* a wetland plant, giving the habitat as "woods bordering ponds (and creeks?), apparently where some surface water stands during wet seasons."

In 1988 McCartney observed *Bumelia thornei* at its type locality in Early County, Georgia (note in files of Georgia Natural Heritage Program) and, as his long, handwritten annotation on a 1985 collection (*Rayner & McCartney 2401*, USCH) makes clear, he realized that the often tall shrub of wetland habitats upon which *B. thornei* was founded could hardly be synonymous with the low plant of well-drained, sandy habitats portrayed in McCollum and Ettman 1977.

Angus Gholson showed me to the type locality of *Bumelia thornei* in May of 1990. Later that year I found a number of additional localities for genuine *B. thornei*, including several county records (Anderson 1996). Unaware of McCartney's observations, I came to the same conclusion, that *B. thornei* was not conspecific with the low plant of dry places in southeastern Georgia. The following year I provided a corrected description of *B. thornei*, in an update of *Georgia's Protected Plants* (McCollum & Ettman 1991), as a tall shrub of wetland habitats, known in Georgia (then) only from the southwestern part of the state.

This begged the question of what to call the low, large-fruited plant of dry, sandy habitats of south*eastern* Georgia. The combination of large fruit and comparatively small leaves with patchy, persistent hairs beneath, as well as the habit and habitat, invited comparison with one of the taxa restored to species status in Godfrey 1988: *Bumelia rufotomentosa* [*Sideroxylon rufohirtum*], considered to be endemic to north peninsular Florida. For example, McCartney's 1988 typewritten annotation of *D.A. Rayner & R. McCartney 2401* (USCH) states, "The Tattnall County material most resembles *B. rufotomentosa* from central Florida

[3]The treatments of Small (1900), C ark (1942), Cronquist (1945, 1949) and others based almost exclusively on herbarium collections contain errors regarding (mature) fruit size; sometimes the upper l'mits are given as too large, apparently based on the inclusion of misidentified material, sometimes too small, due to misjudging the state of maturity of unripe fruit on older, discolored specimens. Smal , for example, described his *Bumelia rufotomentosa* (*Sideroxylon rufohirtum*) as having slightly smaller fruits than *B. reclinata*, when in fact they are distinctly larger at maturity

which occurs in similar habitat but has more orbicular, persistent leaves. May represent a new taxon!"

In the early 1990s Carl Nordman, during surveys of rare species and natural communities of the Altamaha River basin for The Nature Conservancy of Georgia, found several new localities for the seemingly anonymous *Sideroxlon* in Appling, Pierce, Tattnall and Toombs Counties; vouchers for eight of these have been cited herein. I also maintained an interest in the plant, looking for it whenever my work for the GaDNR took me to the southeastern part of the state and making the first collections from Candler and Treutlen Counties. In 1996–97, I conducted for the GaDNR, with funding from the U.S. Fish and Wildlife Service, a status survey of *Sideroxylon thornei* and of the low plant of sandy places that had been mistakenly included within it (Allison 2000). Soon thereafter I shared my findings and some specimens with an authority on *Sideroxylon*, Loran Anderson. Informally, in an abstract, we indicated our intention to name the plant *S. duncanorum* (Allison & Anderson 1998). The proposed specific epithet was to commemorate a lifetime of service to southeastern botany on the part of the late Wilbur H. Duncan and of his wife and work partner, Marion B. Duncan. I plan, instead, to name another Georgia endemic shrub (of the Lamiaceae) in their honor.

While working up the manuscript for the "new species" of *Sideroxylon*, I came across the name *Bumelia macrocarpa* Nutt. among synonyms of *B. reclinata* listed in Clark 1942. Nuttall's choice of an epithet meaning "large-fruited" demanded further inquiry, as this name would be very appropriate for the Georgia endemic. Furthermore, I recalled that Nuttall collected the type of *Arenaria brevifolia* Nutt. ex Torr. & A. Gray [=*Minuartia uniflora* (Walt.) Mattf.] from Tattnall County, Georgia (Harper 1904), placing him in the vicinity of extant locations of the supposedly undescribed Georgia buckthorn.

In May of 2005 I examined the only sheet (Fig. 1) of Nuttall's *Bumelia macrocarpa* at the Academy of Natural Sciences, Philadelphia (PH). It bears five fragments of *Sideroxylon* and three paper labels: (1) a primary label that can be no older than 1878 (19 years after Nuttall's death), as it identifies the sheet using Gray's combination, *B. lanuginosa* var. *macrocarpa*; (2) Clark's 1940 annotation label, identifying the sheet as *B. reclinata*; and (3) pierced by one of the fragments, a scrap with two handwritings. On the latter was written in pencil: "B. [blank space for a specific epithet]. Fruit large as a small date! Eatable. Geo." According to James Lendemer of PH (pers. comm.), Charles Pickering, a curator of PH and close friend of Nuttall's (Graustein 1967) probably assembled and mounted this material from Nuttall's disorganized and voluminous material at PH, and supplied the annotations in black ink on Nuttall's scrap of a label: the specific epithet "*macrocarpa* Nutt.," the quotation marks surrounding the original penciled text, and the identification of the penciled handwriting as Nuttall's. This label is unquestionably Nuttall's, as it conforms exactly to his practice in

this regard, as described by Graustein (1967). Only the fragment piercing this label, as discussed near the end of the introduction, is a match for Nuttall's description of *B. macrocarpa* and for the specimens cited above, under additional collections examined. Although Nuttall did not specify a type collection, this specimen is housed in the institution where he worked for many years, both before and after the presumptive collection date of 1830. Therefore I designate the fragment at upper left as the lectotype.

HABITAT

The habitat of *Sideroxylon macrocarpum* is sandy, well-drained, and dry-mesic, but apparently not quite dry enough for the partly sympatric *Chrysoma pauciflosculosa* (Michx.) Greene or *Ceratiola ericoides* Michx. to occur. The great majority of occurrences have a well-developed overstory of *Pinus palustris* P. Mill., with fire infrequent enough (or excluded long enough) to permit arborescent oaks to attain flowering size. The latter may include *Quercus margaretta* Ashe ex Small, *Q. incana* Bartr., *Q. laevis* Walt., *Q. marilandica* Muenchh. and/or *Q. hemisphaerica* Bartr. ex Willd.

Sites that seemed otherwise suitable but had been subjected to significant soil disturbance (e.g. chopping and bedding) were usually devoid of the plant, though occasionally a few survivors could be found. The plant's growth form, with the majority of its biomass beneath the litter layer, seems a clear adaptation to episodic fires as well as for conserving water. Some perennials are promoted by root fragmentation due to chopping and other soil disturbances associated with currently prevalent forestry practices. *Sideroxylon macrocarpum* clearly does not tolerate these practices well.

Aside from *Pinus palustris* and the oaks listed above, the tree most frequently recorded in association with *Sideroxylon macrocarpum* was *Prunus serotina* Ehrh. Shrubs or woody vines recorded as common associates of *S. macrocarpum* were *Licania michauxii* Prance, *Morella cerifera* (L.) Small, *Opuntia humifusa* (Raf.) Raf., *Gelsemium sempervirens* (L.) St. Hil., *Toxicodendron pubescens* P. Mill., and *Vitis rotundifolia* Michx. Frequent herbaceous associates included *Aristida stricta* Michx., *Baptisia perfoliata* (L.) R. Br. ex Ait. f., *B. lanceolata* (Walt.) Ell., *Eriogonum tomentosum* Michx., *Cnidoscolus stimulosus* (Michx.) Engelm. & A. Gray, *Pteridium aquilinum* (L.) Kuhn, *Tephrosia virginiana* (L.) Pers., and *Vernonia angustifolia* Michx. (data from Allison 2000).

Exceptions to the preceding habitat characterization include powerline rights-of-way and road shoulders, where the plant grows in more exposed situations. Here the adverse, drying effects of more sunlight reaching the substrate are apparently counterbalanced by a regular mowing or bush-hogging regime. The latter must surely have much more impact on taller competitors than on the low-growing *Sideroxylon*, promoting its persistence and increase as a result of decreased competition.

COMPARISONS WITH RELATED TAXA

Whether called *Bumelia* or *Sideroxylon*, the temperate species of the southeastern states have long been considered a natural group. Pennington (1990) states that "they are easily distinguished from all Neotropical species by the combination of fascicled leaves with conspicuously finely reticulate tertiary venation, short-styled flowers, small fruit, and the seed with a bipartite scar." Reflecting this, the five such species recognized by him (*S. lanuginosum*, *S. reclinatum*, *S. thornei*, *S. tenax*, *S. lycioides*) are separated, under the first couplet, from all others in his key to the species of *Sideroxylon*. More than century earlier, Gray (1878, 1886), treating all of these taxa except the then-undescribed *thornei*, emphasized the deciduous leaves and "staminodia nearly as large as the proper [medial segments of the] corolla-lobes" as unifying characters.

At one time or another, plants of *Sideroxylon macrocarpum* have been confused with each of the abovementioned species except *S. tenax* and *S. lycioides*. In fact, as discussed earlier, it is most similar not to any of these but to a less well known taxon completely ignored by Pennington, the one now known as *S. rufohirtum*.

Sideroxylon tenax and the closely related *S. alachuense* stand apart from all these species most conspicuously by their densely sericeous-tomentose lower leaf-surfaces, the pubescence mostly tawny or rufous in the former, mostly silvery in the latter. *Sideroxylon lycioides* differs from all except *S. reclinata* s. str. in having leaves that are normally glabrate beneath; the former has consistently larger leaves and fruit than the latter. *Sideroxylon macrocarpum* is readily distinguished from these two taxa by the leaves persistently, if rather sparsely, strigose beneath and by occurring in better drained, sandier habitats than is normal for them. However, populations of *S. reclinatum* from south peninsular Florida, described (Whetstone 1985) as *Bumelia reclinata* var. *austrofloridensis* Whetstone, are more similar to *S. macrocarpum* in having persistent leaf-pubescence; but the small fruit size (≤ 9 mm long) and staminodes equaling or exceeding the corolla-lobe appendages, indeed indicate closer affinity to *S. reclinatum* s. str. than to *S. macrocarpum*.

It seems unlikely that Gray had ever seen material of *Bumelia macrocarpa* when he reduced it to a variety of *B. lanuginosa*, but he probably felt that the persistent foliar pubescence emphasized by Nuttall ruled out synonymizing it under *B. lycioides* or *B. reclinata*. Perhaps Nuttall's use of the term "lanuginous" to describe the vestiture influenced Gray to place it with *B. lanuginosa* and not *B. tenax*. *Sideroxylon lanuginosum* is clearly a heterogeneous taxon, especially as regards coloration, density, and persistence of foliar pubescence, with three subspecies accepted by Pennington (1990). Only *S. lanuginosum* s. str. is known from Georgia or Florida, however, and like *S. tenax*, *S. lanuginosum* subsp. *lanuginosum* has lower leaf surfaces with a persistent pubescence dense enough

to obscure all or most of the laminal surface, while in *S. macrocarpum* and *S. rufohirtum* the hairs are much sparser, the majority of the surface always visible once the leaves are fully expanded. Among the other subspecies of *S. lanuginosum*, only subsp. *rigidum* (A. Gray) Pennington invites comparison with *S. macrocarpum*, by virtue of its small leaves with a foliar pubescence sometimes resembling that of the Georgia endemic. The fruit of *S. lanuginosum* subsp. *rigidum* is unknown to me; however, this plant of the southwestern U.S.A. and northern Mexico is a "shrub or small tree to 8 m" (Pennington 1990).

No doubt the similarity of foliar pubescence was largely responsible for Cronquist's confusion of specimens of *Sideroxylon macrocarpum* with *S. thornei*. While these species do share a similar pubescence and comparatively large fruit size, they exhibit major differences in habit and habitat. *Sideroxylon thornei* is a larger-leaved (to as much as 13.9 cm long [Anderson 1996]), erect and potentially tall shrub or small tree of wetlands, usually associated with *Taxodium*, whereas *S. macrocarpum* is a small-leaved (rarely to 5.2 cm), sprawling shrub less than a meter tall, adapted to well-drained upland woodlands dominated by *Pinus palustris* and various species of *Quercus* L.

As stated previously, *Sideroxylon macrocarpum* is more similar in habit and habitat to the allopatric *S. rufohirtum* than to any other species. They differ in several minor respects and in at least two major ones, androecium (including staminode) size and seed coloration, as indicated in Figure 2 and Table 1.

The known ranges of *Sideroxylon macrocarpum* and *S. rufohirtum* are separated by roughly 190 km (120 miles). Most of this intervening territory is inhospitable to species requiring well-drained soils, as it consists (or consisted, prior to human alteration) largely of lowlands, wetlands and bodies of water, most conspicuously the Okefenokee Swamp. A change in broad-scale landscape within the gap in the two ranges is apparent at once from an examination of a Georgia landcover map (Canalos & Clover 1993), in which the most abundant cover class assigned throughout the range of *S. macrocarpum* is "cultivated/exposed earth." South of this region the Okefenokee is apparent from a glance at this map, but with closer study an area more than twice its size immediately to its west is also well differentiated. This region remains dominated by forest land, reflecting the area's comparative unsuitability for agriculture, presumably due to its being insufficiently well-drained (Christopher Canalos, pers. comm.).

I consider it likely that these two buckthorns are sibling species, now geographically isolated in large part by the development of the Okefenokee and lowlands to its west. Although the oldest peat deposits from the Okefenokee have been radiocarbon dated at a little less than 7000 years B.P., for many years prior to the period of peat accumulation the landscape there was dominated by freshwater marshes (Cohen et al. 1984). Because the Okefenokee developed in a basin formed during one of the last great transgressions of the Atlantic Ocean over southeastern Georgia, during the very late Pliocene or earliest Pleistocene

TABLE 1. Morphological comparison of *Sideroxylon macrocarpum* and *S. rufohirtum*.

Sideroxylon macrocarpum	*Sideroxylon rufohirtum*
Stems usually copiously thorny; galls rarely observed (e.g. *Allison 12220*, GA)	**Stems** less thorny; often with galls (Godfrey 1988)
Leaves usually narrowly oblanceolate or spatulate	**Leaves** usually broadly but sometimes narrowly oblanceolate, spatulate, etc.
Twig and leaf trichomes mostly whitish or translucent, generally less abundant	**Twig** and leaf trichomes rufous (rusty brown), generally more abundant
Pedicels short, 1–3(–5.5) mm	**Pedicels** longer (1.8–)3–6(–8.5) mm
Sepals unequal (outer 2 shorter), pubescence sparse to moderate	**Sepals** ± equal in length, pubescence moderate to dense
Corolla (3.1–)3.7–4.8 mm; medial lobe-segments broadly obovate, lateral segments relatively narrow	**Corolla** 3.8–5.0 mm; medial lobe-segments relatively narrow, lateral segments broader than in *macrocarpum*
Style 1.0–1.3(–1.5) mm	**Style** (1.5–)1.7–1.9 mm
Ovary glabrous or medially villosulous	**Ovary** covered with hairs
Anthers 1.1–1.3(–1.5) mm, filaments 1–2 mm	**Anthers** 0.7–0.9(–1.0) mm, filaments 1.5–2.1 mm
Staminodes (1.2–)1.3–1.8(–2.0) mm, reaching (1/3–)1/2 to 2/3 the length of the medial corolla-lobe segments and exceeded by the lateral segments	**Staminodes** (1.7–)2.0–2.5 mm, nearly reaching the length of the medial corolla-lobe segments and exceeding the lateral segments; occasionally with sagittate bases
Seed evenly brown	**Seed** variegated (brown and yellowish) at maturity

(Rich 1984), the area was unsuited to plants of well-drained soils for at least several millennia prior to 7000 years B.P. The similarity of the habitats of *Sideroxylon macrocarpum* and *S. rufohirtum* does suggest an alternative explanation: that their comparatively large fruit and low stature resulted from parallel or convergent evolution, and not direct descent from a common ancestor.

Whatever the cause, *Sideroxylon macrocarpum* has been isolated reproductively long enough to consistently exhibit at least one morphological extreme within the temperate species-group endemic to the southeastern U.S.A.: a smaller size of staminode relative to corolla lobe. Since it is further differentiated from the similar but allopatric *S. rufohirtum* by having evenly brown mature seeds rather than variegated ones, I have no hesitation in recognizing the Georgia plants at the level of species.

CONSERVATION STATUS

The range-wide decline of *Pinus palustris*-dominated communities due to fire suppression, conversion to other forest types or to farmland, pasture and, increasingly, residential uses, is too well-documented to require discussion here. Whether *Sideroxylon macrocarpum* as a species has suffered the same degree of decline over the last century, or any decline at all, cannot be shown by my

observations, due to a lack of baseline data. Since populations seem best developed where there is a moderate oak understory, it seems likely that fire suppression, where not too rigorous or prolonged, has benefited mid-successional species like *S. macrocarpum*, at least in some relatively xeric habitats over deep sands. Too short a fire interval, with too-frequent destruction of aboveground biomass, outweighs the benefit of reduced competition. The converse: too-prolonged exclusion of fire from the habitat leads to excessive shading from closing of the canopy and crowding out by non-fire-adapted competitors.

Immediate threats to *Sideroxylon macrocarpum* arise chiefly from conversion of its habitat to short-rotation "industrial" pine plantation. Impacts from current practices include soil disturbance (damage to the deep root system), herbicide use (to kill competitors of pine, such as *Sideroxylon*), and fertilizer application. The latter is of no benefit to plants, like this species, that have evolved adaptations making them tolerant of nutrient-poor soils and giving them a competitive advantage there, while fertilization is distinctly beneficial to broadly-adapted, weedy competitors, both native and exotic.

Another cause for concern is the movement away from mowing as a means of maintaining rights-of-way and toward a dependence on herbicides. As discussed above, mowing can provide a competitive advantage to low-growing species such as *Sideroxylon macrocarpum*. Herbicide use, by contrast, leads to their replacement over time by a few herbicide-resistant species, which would seem eventually to require either a return to mowing or changes to the herbicide regime.

At present, as the many collections cited above from the last two decades attest, the plant is not extremely difficult to find within suitable habitat in the part of Georgia to which it appears to be endemic. However, I suggest consideration be given to amending the list of plants receiving protection under the Georgia Wildflower Preservation Act, to replace *Sideroxylon thornei* with *S. macrocarpum*, for several reasons. For one, as indicated earlier, the apparent intent in listing *B. thornei* was to provide protection to the plant now known as *S. macrocarpum*, the result of mistaken specimen annotations by Cronquist in 1970. Secondly, genuine *S. thornei* is now known to be much more widespread and abundant than was once believed (Patrick et al. 1995; Anderson 1996; Allison 2000), with a fair number of occurrences on public lands. Furthermore, the wetland habitats of *S. thornei* receive protection under the federal Clean Water Act (CWA), without regard to any rare species that may be present. This law affords a much greater level of protection to wetland plants than is provided by state or federal protected species laws, which provide little or no *habitat* protection to plants. The CWA provides no benefit to obligate upland species such as *S. macrocarpum*, part of the suite of longleaf pine associates so famously in decline; it serves instead to channel development away from wetlands and into habitats like those of *S. macrocarpum*. Finally, I believe that each

state wildlife agency should recognize a special responsibility to provide for the welfare of those species found nowhere except within the borders of its state.

Of course, the intention of laws like Georgia's Wildflower Protection Act is to prevent additional species from suffering the same fate as the dodo (*Raphus cucullatus*): extinction. This famously extirpated flightless bird of Mauritius is an especially appropriate example because of the link posited by Temple (1977) between its eradication and the decline there of a congener of *Sideroxylon macrocarpum*, *S. majus* (Gaertn. f.) Baehni (syn.: *Calvaria major* Gaertn. f.). In brief, Temple averred that the *Sideroxylon* was represented by a few trees estimated to be more than 300 years old, despite the regular production of well-formed fruit. He theorized that the supposed absence of reproduction in the *Sideroxylon* was due to the extinction of the dodo, which presumably scarified the seeds in its gizzard after ingestion of the fruit and that this was required for their germination. He tested this by force-feeding seeds of the *Sideroxylon* to domesticated turkeys, after which he extracted some of the seeds from the scat and successfully germinated a few of them.[4]

Whether Temple's hypothesis is correct or not (for a contrary view see Owadally & Temple 1979), it seems possible that the comparatively large fruit size of *Sideroxylon macrocarpum* and of its sibling species, *S. rufohirtum*, reflects natural selection to make the fruit more attractive to another terrestrial animal of conservation concern, the gopher tortoise (*Gopherus polyphemus*). The range of *S. macrocarpum* is nested entirely within the range (mapped in Auffenberg & Franz 1982) of this turtle, which is often syntopic with the *Sideroxylon* today (pers. obs.; Fig. 5). It is probable that, prior to the serious decline of the tortoise, it was a regular associate of the buckthorn in the open, well-drained, sandy habitat required by the plant and favored by the reptile. The low stature of this shrub certainly places its fruit within easy reach of the tortoise, though admittedly this may be a secondary result of selection due to recurrent fires that are thought to be required to maintain ideal habitat for both species. It must also be admitted that fruit size in *Sideroxylon* is probably correlated with seed size, and that the greater storage capacity of larger seeds has survival value in drought-prone habitats. Frugivory by *Gopherus* may not have been the primary selective force promoting lower stature and larger fruit. But it should also be noted that, compared to the species with which they have been confused, the large fruits of *S. macrocarpum* and *S. rufohirtum* more closely resemble a fruit reported to be commonly consumed by gopher tortoises: that of *Serenoa repens* (Bartr.) Small (Breininger et al. 1986). As in *S. macrocarpum* and its relatives, the fruit of this native palm is a black, fleshy, mostly subglobose fruit, most of whose volume is occupied by a single large seed (as figured in Uhl

[4]In 1978 this purported case of coevolution of bird and tree was a subject of one of the celebrated series of essays by the late Stephen A. Gould, *This View of Life*, in the popular scientific magazine *Natural History*.

& Dransfield 1987). Birkhead et al. (2005), analyzing gopher tortoise scat, unfortunately from outside the geographic range of either *S. macrocarpum* or *S. rufohirtum*, reported ingestion by gopher tortoises of the large-seeded fruits of several dicotyledonous genera, including *Asimina* Adans., *Licania* Aubl., and *Prunus* L., and found that such seeds were defecated intact. They concluded that these animals play an important role as dispersal agents for plants with large-seeded fruits in pine savannas of the Southeast. It should also be noted that the gap separating the ranges of *S. macrocarpum* and *S. rufohirtum* (see discussion above, following the table) corresponds roughly to a gap depicted on the generalized range map of *Gopherus polyphemus* appearing in Ernst et al. 1994.

Let us hope that future generations will be able to see—if not the hapless dodo—thriving populations of gopher tortoises, big-fruited buckthorns, and as wide a spectrum as possible of the rest of the incalculable diversity of life-form bequeathed and entrusted to us all. We have the means; it remains to be seen whether we also have the will.

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SEXUAL AND APOMICTIC PRAIRIE FLEABANE (*ERIGERON STRIGOSUS*) IN TEXAS: GEOGRAPHIC ANALYSIS AND A NEW COMBINATION (*ERIGERON STRIGOSUS* VAR. *TRAVERSII*, ASTERACEAE)

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ABSTRACT

The reproductive mode (sexual diploid vs. apomictic polyploid) of prairie fleabane (*Erigeron strigosus* Muhl. ex Willd.) in Texas was estimated through the analysis of pollen quality for herbarium specimens from the Botanical Research Institute of Texas (BRIT) and the University of Texas (TEX). The approximate geographic coordinates for 285 unique collections were determined and geographic distributions of sexual vs. apomictic plants were plotted using Geographic Information System (GIS) software. The species as a whole occurs throughout the eastern half of Texas, although one outlying specimen was recorded from the northern Panhandle. Apomictic plants were far more common than sexual plants (245 vs. 40 specimens), and exhibited greater ecological amplitude with respect to natural area, precipitation, and soil. Sexual plants were restricted to Pineywoods and Post Oak Savannah habitats in extreme eastern Texas, and correspond to *Erigeron traversii* Shinners. This taxon was described in 1964 but subsequently included as a synonym of *E. strigosus*. This geographical pattern is similar to that recorded for other taxa that include sexual and apomictic populations. The new combination ***E. strigosus*** var. ***traversii*** (Shinners) Noyes is proposed.

RESUMEN

El modo de reproducción (diploide sexual vs. poliploide apomíctico) de *Erigeron strigosus* Muhl. ex Willd. en Texas se estimó mediante el análisis de la calidad del polen en especimenes de herbario del Botanical Research Institute de Texas (BRIT) y de la Universidad de Texas (TEX). Se determinaron las coordenadas geográficas aproximadas de 285 colectas y se representaron las distribuciones geográficas de plantas sexuales contra apomícticas usando un software de Sistemas de Información Geográfica (GIS). La especie en conjunto está por la mitad este de Texas, aunque se registró un espécimen del norte de Panhandle. Las plantas apomícticas fueron mucho más frecuentes que las sexuales (245 vs. 40 especimenes), y mostraron mayor amplitud ecológica con respecto al área natural, precipitación, y suelo. Las plantas sexuales estuvieron restringidas a hábitats de pinares y robledales en el extremo este de Texas, y corresponden a *Erigeron traversii* Shinners. Este taxon se describió en 1964 pero después fue incluido como sinónimo de *E. strigosus*. El patrón geográfico es similar al registrado para los otros taxa que incluyen poblaciones sexuales y apomícticas. Se propone la nueva combinación ***E. strigosus*** var. ***traversii*** (Shinners) Noyes.

Many plant taxa in temperate regions include both sexually and apomictically reproducing populations (Gustafsson 1946–1947; Grant 1982; Asker & Jerling 1992). These taxa occur predominantly in the Asteraceae, Rosaceae, and Poaceae, and include diplosporous apomicts (the unreduced gametophyte arising di-

rectly from divisions of the megaspore mother cell) as well as aposporous apomicts (the unreduced gametophyte arising from a vegetative cell of the ovule). Apomictic taxa are almost always polyploid, and though they produce genetic clones through maternal function, they also usually produce reduced pollen that can function in crosses with facultative apomicts and sexual plants. The latter are frequently restricted to the diploid level. Apomictic populations and sexual populations may have different distributions, a pattern that is referred to as geographic parthenogenesis. Apomicts, relative to sexuals, have larger ranges, range into higher latitudes, range to higher altitudes, and have a greater tendency to colonize once-glaciated areas (Bierzychudek 1987).

In plants, pollen quality is highly diagnostic for mode of reproduction (Gustafsson 1946–1947). Sexual plants typically produce pollen of uniform size and high viability as estimated with pollen vital stains. Apomictic plants, on the other hand, produce pollen that is of relatively low quality, with high variation in size, a high proportion of aborted grains, and often including miniature aborted pollen grains (i.e., micrograins). These distinguishing features are readily observed from pollen samples obtained from fresh pollen samples as well as from herbarium specimens.

Erigeron strigosus Muhl. ex Willd., the prairie fleabane, is abundant in the United States from the Atlantic coast to the Great Plains and occurs sporadically in the West (USDA, NRCS 2005). The species has been considered to be uniformly apomictic in monographs (Cronquist 1947) and floristic treatments (e.g., Barkley 1986; Hickman 1993). Diplospory was documented cytologically (Holmgren 1919) and most of the published chromosome number counts for the species are triploid (2n = 27; 14 / 38 counts = 37%), tetraploid (2n = 36; 6 / 38 counts = 16%), or hexaploid (2n = 54; 4 / 38 counts = 11%) (Compiled from Index to Plant Chromosome Numbers, 1955-2000). Nesom (1978), however, based on diploid counts (2n = 18) from Alabama, Louisiana, and Florida, considered the strong likelihood of sexual populations of *E. strigosus* in the southeastern United States. Sexual reproduction was subsequently verified cytologically for diverse diploid populations in the southeastern United States (Noyes & Allison 2005). Sexual diploid populations included *E. strigosus* var. *calcicola* J. Allison, principally restricted to cedar glades in Tennessee and Alabama, *E. strigosus* var. *dolomiticola* J. Allison, restricted to a single dolomite glade in Bibb Co., Alabama, and plants occurring on the piedmont and coastal plain of South Carolina, Georgia, Florida, and Alabama. In contrast to apomicts, all sexual populations investigated were characterized by tetrasporic ovule development.

The coastal plain is continuous from the Atlantic states to east Texas, and although *Erigeron strigosus* is abundant throughout, biosystematic analysis has been wanting. In addition, *E. traversii* Shinners was described to include subtly distinct plants in the Pineywoods of Texas and adjacent Louisiana that flowered earlier than typical *E. strigosus* (Shinners 1964). Although accepted in the

Manual of the Vascular Plants of Texas (Correll & Johnston 1970), the taxon was later provisionally listed as a synonym of *E. strigosus* owing to the absence of conspicuous morphological characteristics (Johnston 1990). That precedent has been followed in checklists (e.g., Kartesz 1992; Hatch et al. 2001; USDA, NRCS 2005) and floras (Flora of North America, Asteraceae 2006, G.L. Nesom, BRIT, pers. comm.).

The objective of this work was to investigate the occurrence of sexual vs. apomictic plants of *E. strigosus* in Texas based on analysis of herbarium specimen pollen samples. Further, detailed geographic distribution and phenological patterns were analyzed, as was the relationship between reproductive mode and those plants previously identified as *E. traversii*.

METHODS

Specimens were loaned to the University of Colorado (COLO) from the Botanical Research Institute of Texas (BRIT) and the University of Texas (TEX). Pollen was removed from each specimen to estimate mode of reproduction. Five to ten florets that had newly opened or were 1–2 days (estimated) from anthesis were removed from single capitula for each specimen. Florets were placed on a standard microscope slide with ca. 15 µl Cotton blue in Lactophenol (Stanley & Linskens 1974) and allowed to saturate 2 days—1 week. Pollen was released from the softened florets as necessary by tearing a longitudinal slit into the corolla tubes using dissecting needles. Floral debris was removed, a cover slip was applied, and pollen was allowed to stain for ca. 1 week prior to observation. The stained pollen was evaluated visually using bright-field microscopy at 400×. A pollen sample was identified as being produced by a polyploid apomictic plant if it included a high proportion of aborted grains, large grains (usually some grains > 17 µm diam), and / or micrograins. Conversely, a pollen sample was identified as being produced by a sexual plant if it generally included a low proportion of aborted grains, was uniformly small (ca. 12–15 µm diam), and lacked micrograins. Measurements of grains, as required, were performed on pollen images captured and analyzed using AnalySIS (v.3.1; Soft Imaging System, GmbH 1989-2001).

The longitude and latitude of each collection location was determined from the data provided on the herbarium specimen label. This was accomplished initially using the mapping software TOPO! Texas (Copyright 2004, National Geographic Maps, Evergreen, CO) and later using TOPO USA (version 5.0, DeLorme, Yarmouth, ME), facilitated on occasion with text web inquiries using Google (Google, Inc, Mountain View, CA). Locality data were compiled in Excel (version 10.0.4, Microsoft Corp.). If not explicitly stated, distances and directions from towns given on herbarium specimen labels were assumed to lie along existing roads. In most cases, the collection data were sufficient to estimate co-

ordinates with a high degree of confidence. For a few older specimens, only a county or town was provided, in which case coordinates were selected at the geographic center of the county or town. To evaluate differences in the phenology of apomictic vs. sexual plants, collection dates were compared statistically using Excel. This test assumed that the herbarium specimen collection dates, taken as a whole, accurately reflected the duration of flowering in the species.

Localities were mapped using Geographical Information System (GIS) software ESRI ArcInfo (v. 9.0, copyright 1999–2004; http://www.esri.com). Duplicate specimens within or between herbaria were removed from the database so that subsequent analyses were performed only on unique collections. As a check on locality coding, county names for data plotted in ArcInfo were extracted and compared with the original data set. In addition, ca. 20% of the herbarium specimens were selected at random and plotted localities were evaluated for accuracy. Geographic distributions of sexual and apomictic plants were analyzed visually and statistically with respect to rainfall, natural areas, and soils using GIS data layers for Texas available from the Texas General Land Office (http://www.glo.state.tx.us/gisdata), the Texas Park and Wildlife Department (http://www.tpwd.state.tx.us/landwater/land/maps/gis/map_downloads), and the United States Department of Agriculture (http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/data/tx.html), respectively. The soil classification employed followed the taxonomy proposed by the United States Department of Agriculture that recognizes 12 soil orders and 64 soil suborders (Soil Survey Staff 1999). Specific environmental point data for collections were obtained using the Intersect Point Tool (Beyer 2004), and statistical analyses were conducted using Excel.

RESULTS

A total of 311 Texas collections were studied. These included 184 specimens from BRIT and 127 specimens from TEX. In addition, floral material from the holotype of *Erigeron traversii* Shinners (*C.L. Lundell 11,093*, 11 Apr 1942, BRIT) was obtained via special arrangement with curators (185 BRIT Texas collections analyzed, 312 collections total). Twenty collections were duplicated between BRIT and TEX, one collection was represented by two separate sheets at TEX, and three collections were represented by two separate sheets at BRIT. In total, there were 288 unique collections between the two institutions. Three collections (1%), all from TEX, were excluded from subsequent analyses: *G.L. Fisher 38,018* (1938) and *W.R. Carr 11,924* (1992) lacked capitula at a suitable age from which pollen could be obtained, and the locality (even to county) could not be determined for *A. Gieseuschlag s.n.* (1928). The earliest collection (*F. Lindheimer 6978*) was made near Austin in 1844, and the largest portion of specimens (113, 40%) was collected in the 1940s (Fig. 1). Although there were specimens prepared by 95 principal collectors, the majority (52%) was collected by just seven

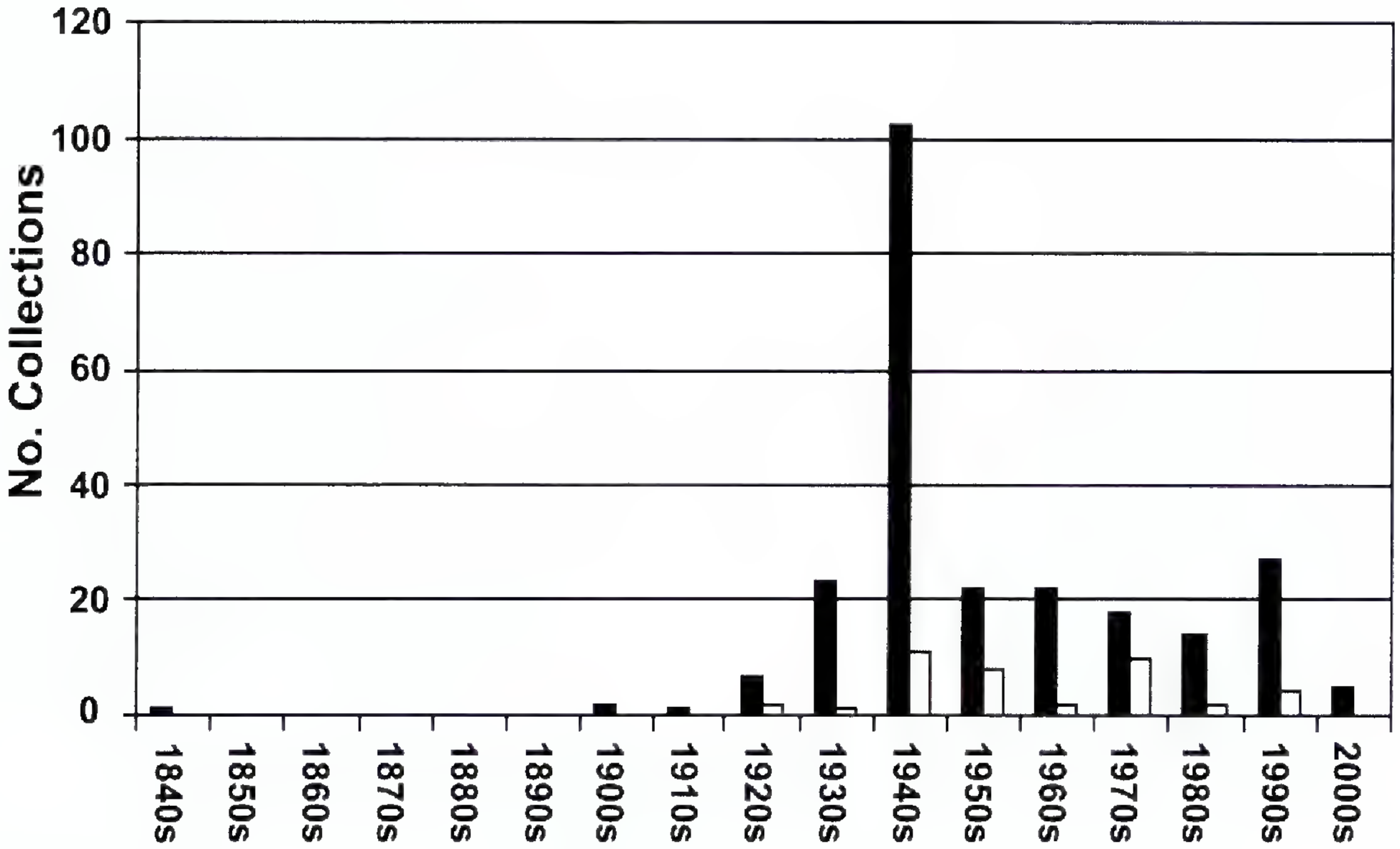


FIG. 1. *Erigeron strigosus* collections by decade in Texas. Solid bars = apomictic (n = 245); open bars = sexual (*n* = 40).

botanists: L. Shinners, 40 (14%); E. Whitehouse, 29 (10%), V.L. Cory, 27 (9.5%), D.S. Correll, 13 (5%); B.C. Tharp, 13 (5%), and C.L. Lundell, 11 (4%), who were prolific in the middle decades of the 20th century, and W.R. Carr, 14 (5%), whose collections were prepared in the 1990s.

The 285 specimens were collected in 87 of 254 Texas counties (Fig. 2A), which are concentrated in north central and east Texas. Most of the collections (87%) were restricted to Pineywoods (88, 31%), Post Oak Savannah, (87, 31%) and Blackland Prairie (73, 26%) (Fig. 2B). The remaining 37 collections (13%) occurred in adjacent regions to the west (Edwards Plateau, 12; Rolling Plains, 14; Llano Uplift, 4) or to the south (Gulf Coast Prairies and Marshes, 5; South Texas Brush Country, 1). Additionally, one specimen occurred in the extreme north Panhandle in Lipscomb County. It was the only specimen to occur in the High Plains region of the state. No specimens were collected in the Trans Pecos region or Coastal Sand Plain of southern Texas. The western boundary of *Erigeron strigosus* in Texas occurs abruptly at ca. 99°W in the central part of the state. This corresponds approximately to the 28 in. precipitation isohyet (Fig. 2C). The Lipscomb county outlier is exceptional in longitude and rainfall, occurring at 100°W in a region with approximately 23 in. annual rainfall.

Of the 285 specimens, 40 (14%) were determined to possess pollen characteristic of sexual diploids, and 245 (86%) were determined to possess pollen characteristic of polyploid apomicts (Fig. 3). Polyploid apomicts occur throughout the range of the species in Texas. Sexual diploid plants, however, were restricted to Pineywoods (34 / 40, 85%) and Post Oak Savannah (6 / 40, 15%).

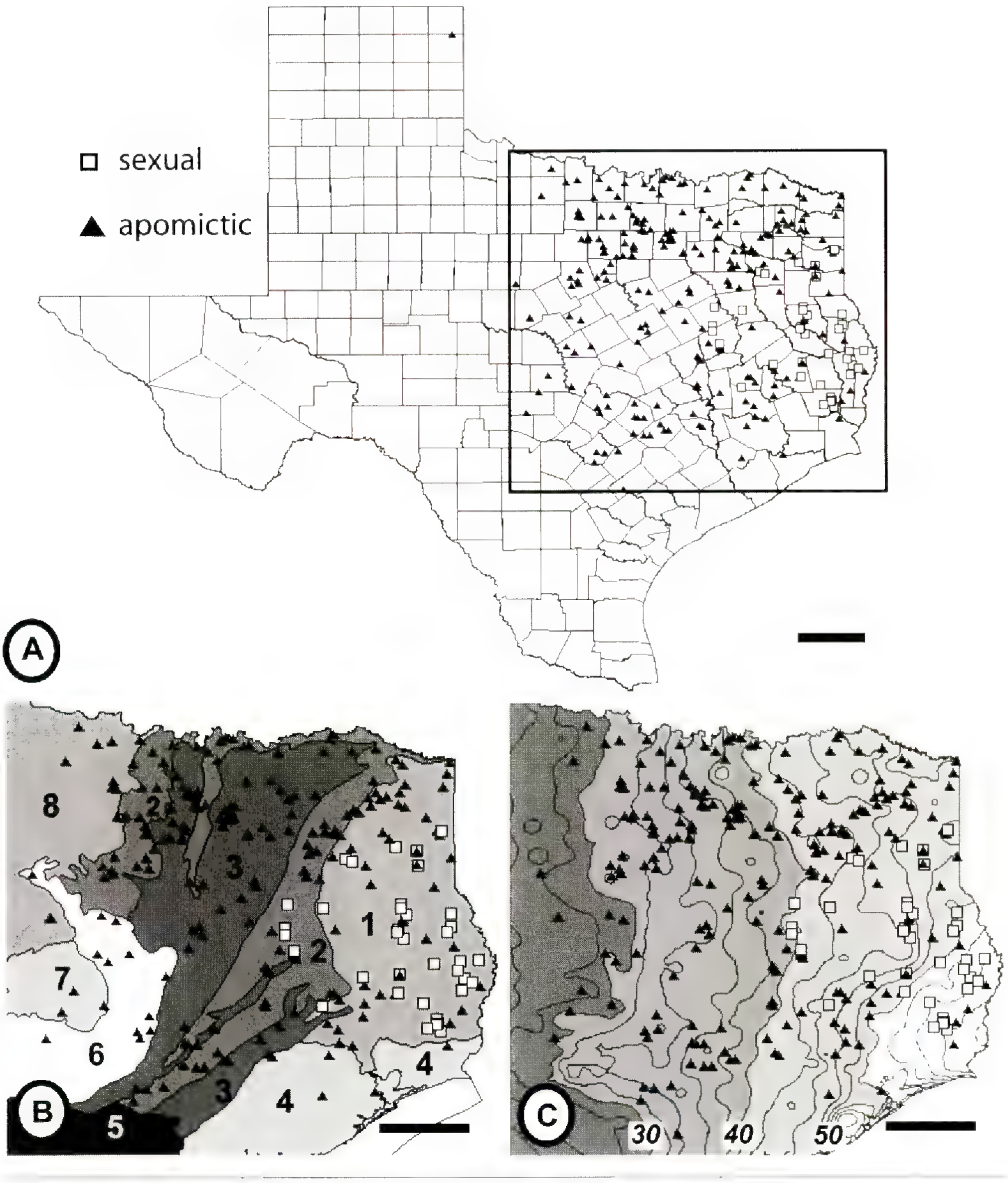


FIG. 2. Geographic distribution of *Erigeron strigosus* in Texas. **A.** Distribution by county. **B.** Distribution by natural area. **1:** Pineywoods; **2:** Post Oak Savannah; **3:** Blackland Prairie; **4:** Gulf Coast Prairie and Marshes; **5:** South Texas Brush Country; **6:** Edwards Plateau; **7:** Llano Uplift; **8:** Rolling Plains. Regions according to Hatch et al. 2001. **C.** Distribution by precipitation. Isohyet values in inches. Scale bars = 100 km.

Sexual plants were collected in 17 counties within these two regions. In six of these counties, only sexual plants have been collected. However, in the other 11 counties, both sexual and apomictic plants have been collected. The oldest sexual specimen was collected by C.L. York in 1928 (*s.n.*, Gregg Co.). There is no significant trend in the proportion of sexual plants collected by decade in the 20th century ($r = 0.19$, $P = 0.58$). This indicates that both sexual and apomictic

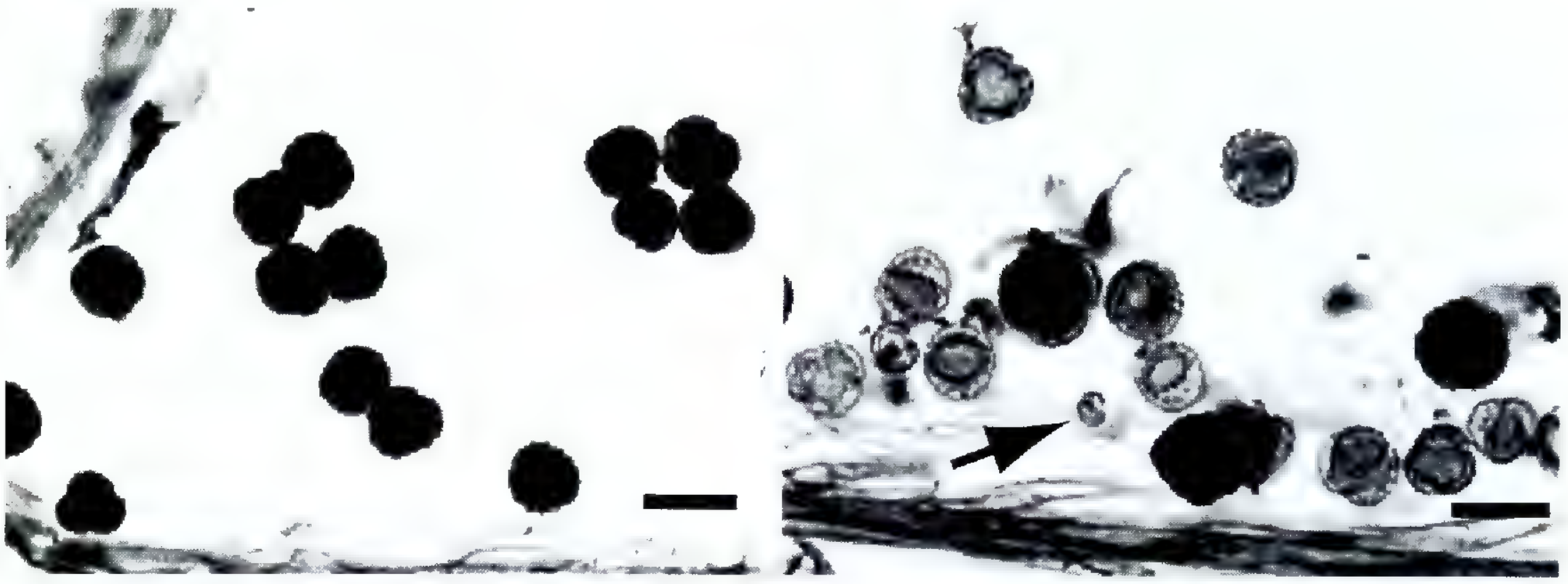


FIG. 3. Pollen from herbarium specimens of *Erigeron strigosus*. **A.** The holotype of *E. traversii* (*C.L. Lundell 11,093*, Nacogdoches Co., BRIT), sexual. **B.** *L.H. Shinners 32,543* (Morris Co., BRIT), apomictic. Arrow indicates a micrograin. Scale bar = 20 µm.

plants have coexisted in Texas since at least the 1920s, and that their relative proportions have not changed dramatically. The holotype of *Erigeron traversii* was determined to have pollen characteristic of sexual diploids, as did the specimens *L. H. Shinners 7618* (BRIT), *18,387* (BRIT), *18,402* (BRIT), *18,450* (BRIT), *18,503* (BRIT), and *B.L. Turner 4377* (TEX), which were cited in the original description of *E. traversii* (Shinners, 1964). *E. Whitehouse 20,861* (BRIT), the eighth specimen cited by Shinners for Texas, was not present among the loan materials.

Precipitation at sites where sexual plants were collected ranged from 41 to 57 in. / year (mean = 48.2 in., SD = 4.9), while values at apomictic sites ranged from 23 to 57 in. / year (mean 39.1 in., SD = 6.3). Precipitation values for apomictic plants, though overlapping, were significantly lower than those for sexual plants (Student t, P = 6.04E-17). Sexual plants predominantly occurred on leached forest soils with subsurface clay (alfisols, 18 collections; ultisols, 18 collections). Four sexual collections occured on poorly developed entisols. Apomictic plants in Oak Savannah and Pineywoods regions also occurred on alfisols (72 collections) and ultisols (28 collections), but also were found on clay-rich vertisols (11 collections), and dark grassland mollisols (12 collections). Six apomictic collections corresponded to entisols.

Collections dates of specimens of *Erigeron strigosus* (Fig. 4) indicate that flowering commences in March, peaks in April and May, and continues sporadically at reduced levels until October or early November. One exceptional apomictic specimen (*R.J. Fleetwood 10,050*, Nacogdoches Co., TEX) was collected 5 Jan 1972 (the collector noted the presence of ice on the plant). The average collection date for sexual plants (for 39 collections made from March to June) was 22 April (SD = 23.3 days). The average collection date for 210 apomictic plants made during the same time period was significantly later (10 May, SD =

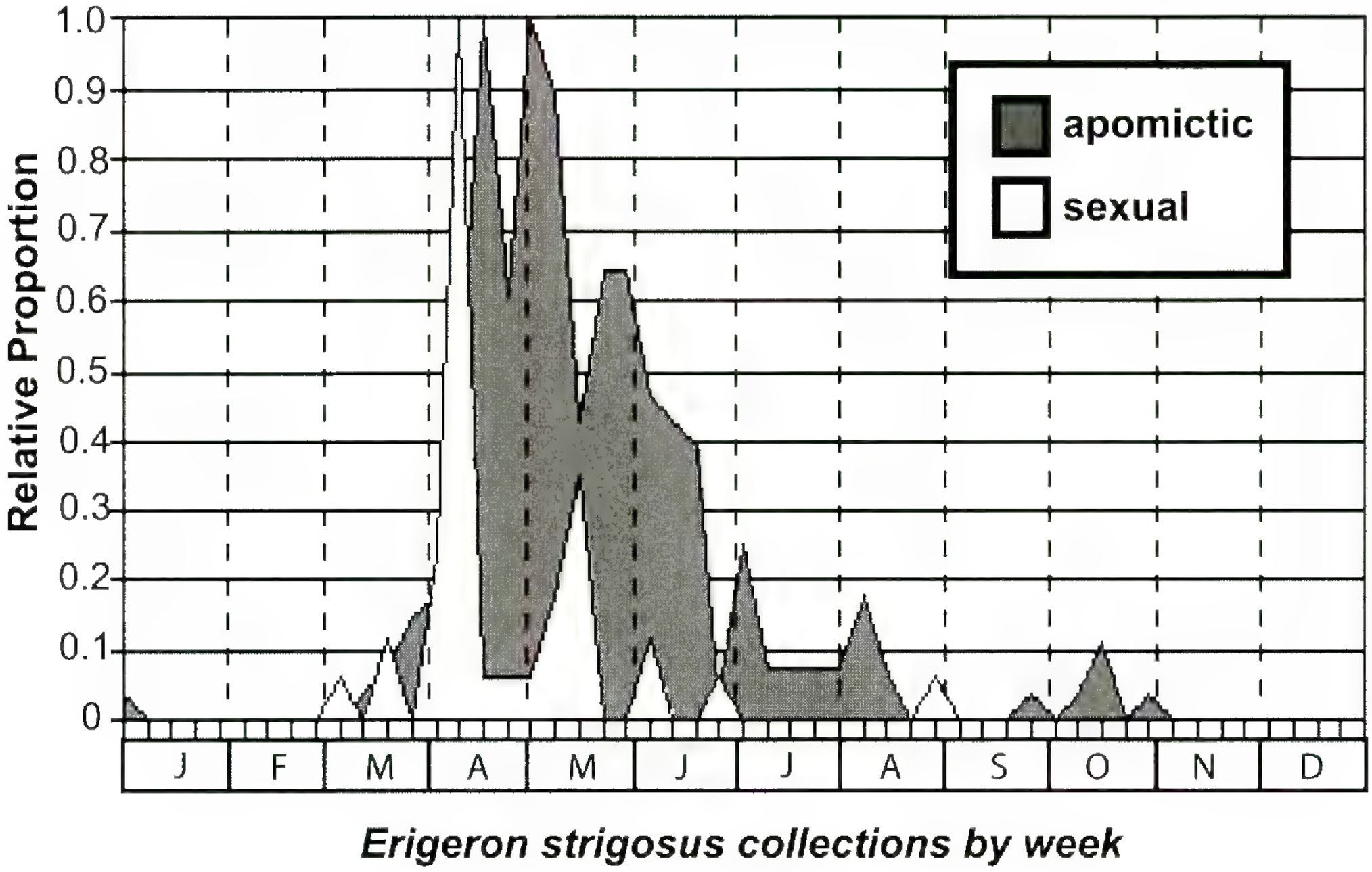


FIG. 4. *Erigeron strigosus* collections in Texas by date. Dates from herbarium specimens grouped by week.

22.5 days, Student t, P = 2.5E-06). The same tendency was observed for asexual plants occurring in only those counties where sexual plants also occurred (n = 22, avg. = 9 May, SD = 20.4 days; Student t, P = 0.006).

DISCUSSION

Sexual and apomictic *Erigeron strigosus* in Texas

The greater range of habitat, precipitation, and soils tolerated by apomictic *Erigeron strigosus* in Texas is consistent with the hypothesis (Baker 1965; Lynch 1984) that asexual lineages, through polyploidy, hybridization, and genome level selection, evolve general-purpose genotypes that are capable of exploiting diverse habitats. However, this pattern is also consistent with the hypothesis that apomictic reproduction may be favored in fragmented marginal habitats because it circumvents the deleterious effects of inbreeding depression and mate scarcity (Haag & Ebert 2004). Detailed, fine-scale analysis of populations, especially in regard to population size, habitat, and disturbance, will be required to differentiate between these two hypotheses. Superficially, the geographic pattern for *E. strigosus* is similar to that for *Taraxacum officinale* in Europe. Sexual diploid populations of that taxon are restricted to low-elevation habitats in south central and southeastern Europe, while apomictic populations are found throughout northern Europe (Den Nijs & Menken 1994).

The historical record indicates that sexual and apomictic *Erigeron strigosus* have co-existed in Texas at least since the early 20th century, and that there-

fore, the two different forms might be in stable equilibrium. Investigations of *E. strigosus* in Georgia document that gene flow from apomicts to sexual diploids may occur, such that progeny of the latter may include a significant proportion of apomicts (Noyes unpublished). Whether or not sexual and apomictic plants occur simultaneously at the same sites in Texas, and hybridize, is unknown. However, because the phenology of the two forms overlaps, hybridization is likely. Hybridization between sexual and apomictic plants has been thought to be important as a source of novel apomictic genotypes (Stebbins 1950) and has been hypothesized to be an important part of the dynamics between apomictic and sexual *Taraxacum* in Europe (Menken, Smit, & Den Nijs 1995; Verduijn, van Dijk, & van Damme 2004). However, in theory, apomictic plants should ultimately replace sexual populations through reproductive advantage (Maynard Smith 1978) or by unidirectional gene flow via pollen from apomictic to sexual plants (Mogie 1992). To determine if apomictic and sexual *Erigeron strigosus* are in dynamic equilibrium in Texas, or if replacement is occurring, detailed demographic study will be required.

Status of *E. traversii* and a new combination

Although not known by Shinners at the time he published the species, pollen evidence indicates that *Erigeron traversii* is a sexual diploid taxon. It is therefore distinct from other *Erigeron strigosus* in Texas, which, based on pollen, is apomictic and polyploid. The analysis of collection dates supports Shinners (1964) observation that *E. traversii*, on average, flowers earlier than *E. strigosus*. Although Shinners documented *E. traversii* in Pineywoods habitats, our data also document the existence of sexual diploids in Post Oak Savannah. According to Shinners, *E. traversii* was distinct in the field from *E. strigosus* in producing showier plants. Whether that difference is due to features of the capitulum (colors, shapes, presentation) or shape and structure of the inflorescence has not been evaluated. These traits, as well as geographic variation among sexual plants, require further study.

The question of whether or not *E. traversii* should be resurrected based on the available evidence is not without controversy. *Erigeron traversii* is distinct from *E. strigosus* in ploidal level and mode of reproduction but the two taxa are sympatric and likely hybridize. However, the sexual taxon appears to be a consistent component of forested habitats of east Texas. To recognize the distinctiveness of *E. traversii* yet acknowledge the close relationship between *E. strigosus* and *E. traversii*, the following combination is proposed:

Erigeron strigosus Muhl. ex Willd. var. **traversii** (Shinners) Noyes, comb. & stat nov. *Erigeron traversii* Shinners, Sida 1:376. 1964. TYPE: U.S.A. TEXAS. Nacogdoches Co.: off US 59, ca. 8 mi S of Nacogdoches, 11 Apr 1942, *C.L. Lundell and A.A Lundell 11,093* (HOLOTYPE: BRIT).

The holotype of *E. strigosus* var. *traversii* shows strong morphological similarity to sexual diploid plants from South Carolina, Georgia, Florida, and Alabama

(Noyes & Allison 2005). In particular, these plants are distinguished by narrowly spathulate rosette and lower stem leaves that bear small, alternate, mucronate lobes along the petiole margin. Thus it is possible that *E. strigosus* var. *traversii* extends continuously from east Texas to South Carolina on the coastal plain and piedmont. Molecular phylogenetic analysis indicates that sexual diploid southeastern populations of *Erigeron strigosus* are distinct from sexual diploid edaphic endemic populations of *E. strigosus* var. *calcicola* and *E. strigosus* var. *dolomiticola* (Noyes 2006a). On the other hand, ongoing geographic mapping for *E. strigosus* indicate that sexual diploid populations occur in western Louisiana, where they are contiguous with those in East Texas, and also in scattered localities in the Ozarks of western Arkansas and adjacent Oklahoma (Noyes 2006b). Detailed biosystematic analyses will be required to determine if these geographically disparate sexual populations constitute a single taxon, or several distinct taxa.

The precise leaf morphology observed in sexual plants of *Erigeron strigosus* has not been observed for apomictic polyploid *E. strigosus*, which may entirely lack petiole lobes, or exhibit larger, more irregular lobing. Variability in apomictic *E. strigosus* is complex, extending from *E. strigosus* var. *septentrionalis* (Fernald & Wiegand) Fernald, which includes plants approaching *E. annuus* (L.) Pers., to apomictic *Erigeron strigosus* var. *strigosus*, which can be very similar to *E. strigosus* var. *traversii*. In addition, the closely related species *E. tenuis* Torr. & A. Gray, also occurs in Texas and adjacent states. The likelihood of hybridization and morphological similarity between early flowering *E. strigosus* (likely corresponding to *E. strigosus* var. *traversii*) and *E. tenuis* was discussed by Van Vleet (1951). Further, based on consideration of published chromosome counts, *E. tenuis* also likely includes sexual and apomictic plants, but the geographic distribution of mode of reproduction in the species is unknown. Thus, elucidation of evolutionary relationships for *Erigeron strigosus* must also include detailed study of *E. tenuis*.

The recognition of *E. strigosus* var. *traversii* brings to three the number of recognized sexual taxa related to the widespread apomictic taxa *E. strigosus*, *E. annuus*, and *E. tenuis* and contributes to our understanding of the evolution and dynamics within the species complex.

The following key is provided to aid in distinguishing *Erigeron strigosus* var. *traversii* from its close relatives in Texas:

1. Pappus of ray and disc florets of numerous conspicuous capillary pappus bristles; the species including both sexual and apomictic plants and in need of taxonomic study _____ **E. tenuis**

1. Pappus of ray florets a low crown-like series of scales, lacking conspicuous capillary pappus bristles, disc florets with capillary bristles.
   2. Plants relatively tall (to 1.5 m) with broad usually pliable leaves; dense, long, flattened trichomes present along the main stem and on the involucre; apomictic and usually triploid; relatively uncommon and restricted to eastern Texas _____ **E. annuus**

2. Plants relatively shorter (to 0.7 m) with narrower, stiffer leaves; flattened trichomes if present, restricted to the base of the plant or relatively sparse or absent; sexual or apomictic.
   3. Plants generally lacking flattened trichomes throughout; plants sexual, diploid; pollen of high quality, relatively uniform in size, grains < 15 µm diam; restricted to Pineywoods habitat in East Texas and adjacent Louisiana _____ **E. strigosus** var. **traversii**
   3. Plant stems and involucres sometimes possessing spreading flattened trichomes; plants polyploid, apomictic, highly variable in morphology; pollen of poor quality, highly variable in size, largest viable grains > 17 µm diam; relatively widespread.
      4. Hairs of involucres flattened, mostly 0.5–1.2 mm; hairs of stems 0.5–1 mm, appressed to spreading _____ **E. strigosus** var. **septentrionalis**
      4. Hairs of involucres terete, mostly 0.1–0.5 mm; hairs of stems mostly 0.1–0.4 mm, appressed to ascending _____ **E. strigosus** var. **strigosus**

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MORE AMERICAN BLACK SAPOTES: NEW *DIOSPYROS* (EBENACEAE) FOR MEXICO AND CENTRAL AMERICA

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ABSTRACT

During the preparation of a monograph of the *Ebenaceae* for Mexico, numerous collections previously determined to be *Diospyros conzattii* Standley and *Diospyros riojae* Gomez-Pompa could not be reconciled with their original descriptions, type specimens and illustrations. It was determined that collections of putative *D. conzattii* from Costa Rica represent a new species, *D. costaricensis*, described here. All but one collection of putative *D. riojae* from the Mexican states of Queretaro, Hidalgo, Tamaulipas, and San Luis Potosi, represent a new species, *D. gomeziorum*, described here. Putative collections of *D. riojae* from Veracruz additionally include specimens of *D. conzattii*, a species previously unreported for the state, and a new species from the Sierra de Los Tuxtlas, *D. tuxtlensis*, described here. We provide emended descriptions of *D. riojae* and *D. conzattii*, and describe three new species of *Diospyros* for Tropical America. We also provide comments on distribution, ecology, conservation, ethnobotany, and provide illustrations for each of these taxa.

KEYWORDS: black sapote, Costa Rica, *Diospyros gomeziorum*, *D. conzattii*, *D. costaricensis*, *D. pergamentacea*, *D. riojae*, *Diospyros rosei* Complex, *D. tuxtlensis*, Ebenaceae, granadilla, guacalillo, Mexico, new species, persimmon, zapote negro silvestre, zapotillo

RESUMEN

Durante la preparación de la monografía de *Ebenaceae* para México, numerosas colecciones previamente determinadas como *Diospyros conzattii* Standley y *Diospyros riojae* Gomez-Pompa no pudieron ser reconciliadas con las descripciones originales, el espécimen tipo y las ilustraciones. Se determinó que la colección putativa *D. conzattii* de Costa Rica, representa una especie nueva, *D. costaricensis* descrita aquí. Todas, excepto una de las colecciones putativas de *D. riojae* de los estados mexicanos de Querétaro, Hidalgo, Tamaulipas y San Luis Potosí representan una especie nueva de *D. gomeziorum*, descrita aquí. Adicionalmente, las colecciones putativas de *D. riojae* de Veracruz, incluyen especimenes de *D. conzattii*, una especie no citada previamente para ese estado y de una especie nueva de la Sierra de los Tuxtlas *D. tuxtlensis*, descrita aquí. Proveemos descripciones corregidas de *D. riojae* y *D. conzattii* y describimos tres especies nuevas de *Diospyros* para América tropical. También hacemos comentarios sobre la distribución, ecología, conservación, etnobotánica y aportamos ilustraciones de todos los taxa.

PALABRAS CLAVE: Complejo de *Diospyros rosei*, Costa Rica, *Diospyros gomeziorum*, *D. conzattii*, *D. costaricensis*, *D. pergamentacea*, *D. riojae*, *D. tuxtlensis*, Ebenaceae, especie nueva, granadilla, guacalillo, México, persimo, zapote negro, zapote negro silvestre, zapotillo

INTRODUCTION

The pantropical genus *Diospyros* (Ebenaceae) consists of about 500 species of trees, shrubs, and suffrutices (White 1983). A treatment of the Mexican species of *Diospyros* in full has not appeared since Standley (1924). Modern treatments have dealt with smaller areas, such as Veracruz (Pacheco 1981), northeastern Michoacan, Guanajuato, and Queretaro (Carranza 2000), the Yucatan Peninsula (Lundell 1942), and the Tehuacán-Cuicatlán Valley, Oaxaca (Kelly 2001), or covered portions of southern Mexico within a larger flora (Whitefoord & Knapp 2001). Circumscription of the Mexican and Central America taxa is not entirely agreed upon. However, based on our preliminary work, a reasonable estimate of the number of native species occurring in Mexico is around 25.

In 1918, C. Conzatti collected a new black zapote from the coastal mountains northeast of San Pedro Pochutla, Oaxaca. He recorded some characteristics of the tree, especially those pertaining to the edible fruit, the taste of which he enjoyed. He believed that the fruit of the 'zapote negro silvestre' (*Conzatti 3167*) had potential as a new tree crop (Standley 1922). This zapote was formally described a few years later as *Diospyros conzattii* Standl. (Standley 1922). According to Trabut (1926), *D. conzattii* was introduced to California and Florida. However, he did not provide any specific details, and we are unaware of any other information that might corroborate the putative introduction of this species to the United States.

Diospyros riojae Gomez-Pompa was described from one fruiting collection made in the Misantla region of central Veracruz, Mexico (Gomez-Pompa 1964). Since then, collections of putative *D. riojae* have been made in several more locations in Veracruz, Tamaulipas, San Luis Potosi, Hidalgo, and numerous places in northeastern Queretaro. *Diospyros riojae* is considered an endangered species (Sánchez-Coello 2002).

During the preparation of a monograph of the Ebenaceae for Mexico, we noticed a large amount of morphological variation among collections of putative *D. riojae* and *D. conzattii*. While we had intended to examine the taxonomy of both species at a later time, in view of the endangered status of *D. riojae*, and a sense of some urgency regarding its protection (e.g., Sosa et al. 1998), we thought it would be prudent to proceed with the treatment of the following taxa now, lest the designation of protected areas, or expensive and time-consuming ecological research, be confounded by the unrecognized presence of similar looking taxa.

About eighty-five specimens from seventeen herbaria were examined for this study. With the exception of one collection from San Luis Potosi, specimens of putative *D. riojae* collected outside of Veracruz represent a new species, *D. gomeziorum*, described here. Much of the material collected in Veracruz and attributed to *D. riojae* has been found to represent *D. conzattii*, and a species

new to science, *D. tuxtlensis*, described here. Costa Rican material, previously ascribed to *D. conzattii*, clearly represents a third new species, *D. costaricensis*, which is described here. These species are best considered members of what we have informally recognized as the 'Diospyros rosei Complex' (Provance & Sanders 2005), a group that additionally includes: *Diospyros rosei* Standl., *Diospyros oaxacana* Standl., *Diospyros palmeri* Eastwood, *Diospyros californica* I.M. Johnston, *Diospyros sonorae* Standl., *Diospyros texana* Scheele, *Diospyros riojae* Gomez-Pompa, *Diospyros conzattii* Standl., *Diospyros rekoi* Standl., *Diospyros torresii* M.C. Provance & A.C. Sanders, *Diospyros morenoi* A. Pool and *Diospyros xolocotzii* Madrigal & Rzedowski. Previously (Provance & Sanders 2005), we called into question the distinctness of *D. morenoi*. At that time, we only had the holotype to examine. Very recent collections from Chiapas, Mexico, have inclined us to reevaluate our position on the status of this species. We now believe that it is a valid taxon, and we plan to address this issue further in the near future.

In this treatment we use 'lanceolate' in the sense of Jackson (1916), being broadest near the lower third of the leaf, not at mid-leaf in the sense of Stearn (2000). 'Scintillant' refers to the sparkling appearance of the epidermis of some plant structures when viewed under a dissecting microscope using bright light. Lengths for winged petioles are unavoidably approximate. Female inflorescences are inferred from fruiting specimens and persistent pedicels, where they are otherwise unknown for these taxa. The leaf venation for most taxa is 'arcolanguid,' defined here as an intermediate state between eucamptodromous and brochidodromous, in which major lateral veins nearly form distinct loops with superadjacent lateral veins, but tardily wane, becoming difficult to distinguish as loops. The term is coined for efficiency and out of necessity, since the term 'eucamptodromous-brochidodromous' of Todzia and Keating (1991) refers to a different type of intermediacy. Geographical coordinates, elevations, and similar estimations when made by us are presented in brackets.

TAXONOMIC TREATMENT

1. Diospyros riojae Gomez-Pompa, J. Arnold Arbor. 45:465. 1964. (**Fig. 1**). TYPE: MÉXICO. VERACRUZ: between Chiconquiaco and Misantla, in *Liquidambar-Quercus* forest, with *Magnolia*, *Meliosma*, *Juglans*, and *Turpinia*, 1350 m, 13 Aug 1962 (fr), *A. Gómez-Pompa 789* (HOLOTYPE: A; ISOTYPES: MEXU, US on fiche from UCSB!). Original material examined: (TYP. IC.: *A. Gómez-Pompa 789*!, J. Arnold Arbor. 45:467. 1964.).

Trees, rarely shrubs, probably facultatively deciduous, to 25 m tall, and to 2.5 m in diameter. (Pacheco 1981); **trunk** channeled, rimose, *bark* dark-brown (Pacheco 1981); **aged stems** subterete to terete, *bark* shallow-fissured with dark ridges, gray and black, *stemwood* pale yellow; **2nd–3rd year stems** short-fissured, glabrous to furfuraceous-pulverulent, puncticulate, lenticellate, half-netted, gray above, tawny below; **current year's stems** angular, smooth to sulcate, glabrous

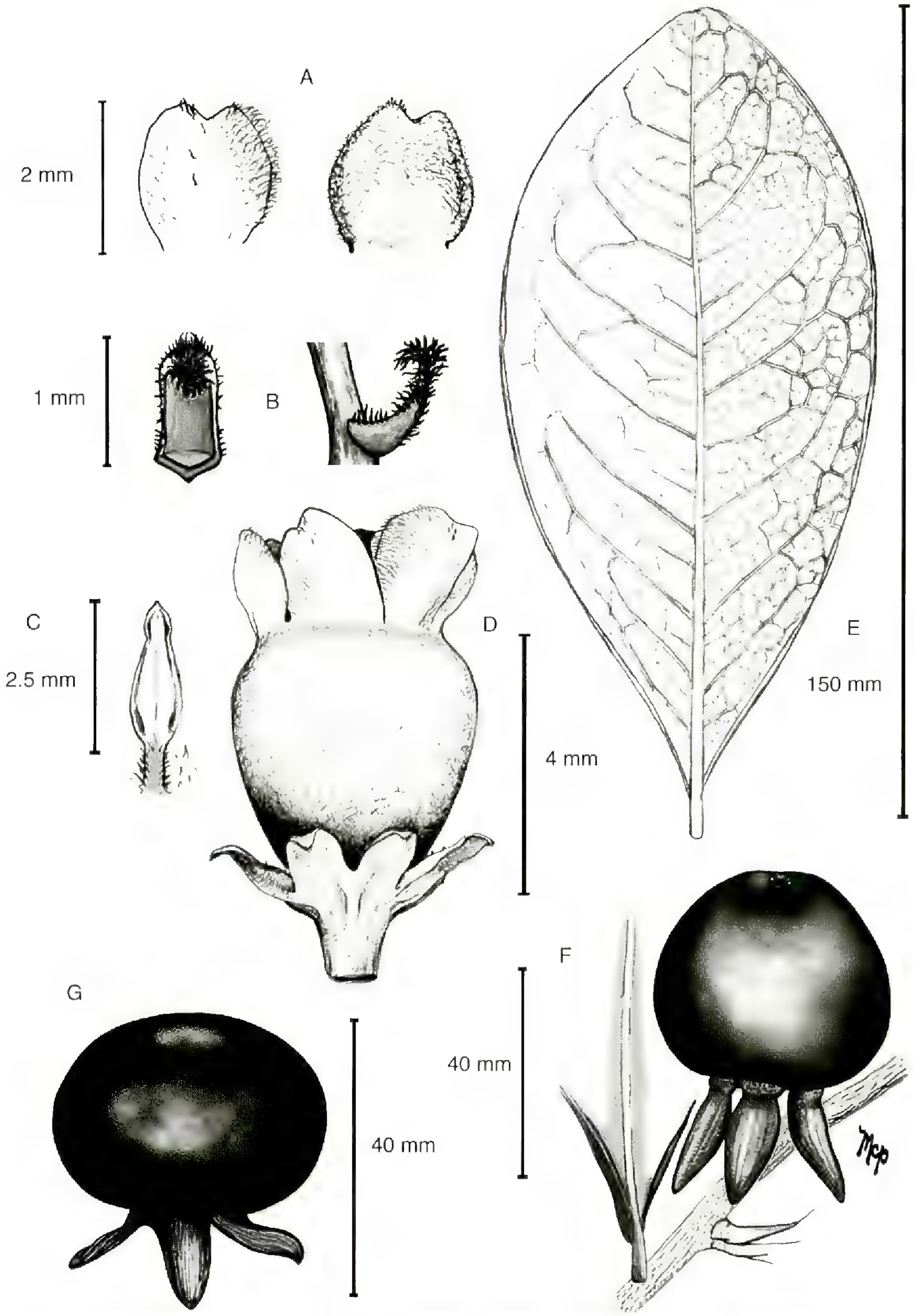


FIG. 1. **A–G.** *Diospyros riojae* Gomez-Pompa. **A.** Abaxial surface (left) and adaxial surface (right) surface of staminate petal lobe. **B.** Adaxial (left) and lateral (right) views of staminate inflorescence bract. **C.** Typical anther. **D.** Staminate flower. E. Abaxial surface of mature leaf showing detail of several degrees of venation. **F.** Fruiting stem. **G.** Fruit. A–D. Based on *F. Ventura A. 15078*. E–F. Based on *J. Becerra Z. 83*. G. Based on *L. Pacheco & J.I. Calzada 18*.

to sparingly subappressed puberulent, hirtellous at the base and near the apex, tan to reddish-brown, glandular. **Petioles** stout, thicker than width, (2–)4–6(–7) mm long, winged, rugose below, slightly pruinose, deeply concave to V-grooved above, ciliolate, glandular. **Leaves** alternate, simple, entire, subcoriaceous to coriaceous, (5–)7–13(–14.2) cm long, (2.5–)3–6(–7.5) cm wide, elliptic, widely elliptic, oblong, widely obovate, sub-oval, *apex* acutely to obtusely rounded, or short-acuminate to a rounded point, *margin* slightly recurved, ± thickened, sometimes ciliolate, *base* obtusely rounded, cuneate, or short-acuminate; **lower leaf surface** glabrous, puncticulate, sometimes slightly pruinose or scintillant, shiny, olive to bronze to brown; **upper leaf surface** glabrous, shiny, pale light-green to gray-green or copper-green, epidermal cells enlarged, the anticlinal walls thickened. **Venation** arcolanguid; **midrib** prominent below, chartreuse to reddish-brown, shallowly concave above, smooth to clavate glandular hairy, shiny, olive to yellow-green; **2°–3° veins** reticulated, raised below, fine with sharp relief, sometimes pruinose-scintillant, granular-papillose, shiny, usually prominent above, *lateral veins* 8–12 pairs. **Laminar extrafloral nectaries** abaxial, near base and midrib, round to narrowly elliptic, sometimes on lateral veins. **Male inflorescence** fascicle, 1–4 flowers from leaf axils of the previous year's growth, or from the base of new stems, sometimes a pair of solitary flowers from the new stem just above the fascicle; **pedicels** 4–7(–10) mm long, sparingly brown to claret velutinous, epidermis green; **pedicel bracteoles** 2, 1 mm long, oblong, ± flat to slightly concave, ascending wavy hairy below, the hairs thick, glistening. **Male flowers** 5-merous; **calyx** infundibuliform; **calyx tube** 1.5 mm long, glabrous or scantly minute subulate hairy; **sepals** triangular to ovate, 1.3–1.8 mm long, 0.7–0.9 mm wide, ciliolate, scantly minute appressed subulate hairy basally, becoming dark glandular wavy hairy apically; **corolla** urceolate-campanulate, tan to brown, reportedly white in living material; **corolla tube** constricted below the lobes, 4 mm long, 3 mm wide, interior grading from glabrous distally to minutely deltoid scaly at mid-tube, again becoming glabrous near the base, except near filament bases, exterior puberulent with hairs erratically directed, some glandular; **corolla lobes** oblong-squarish, emarginate, 2 mm long, 2 mm wide, interior pubescent, exterior minutely sericeous-puberulent, exmedially appressed, several black hairs present near the apex. **Stamens** 18, subexserted, adnate to corolla at mid-tube or lower, some inserted on the receptacle, some lower stamens extrorse, abruptly geniculate, and connected to introrse upper stamens by a superdermal vascular trace; **filaments** 1 mm long, hirtellous, especially on margin; **anthers** basifixed, lance-ovate, ± 2.5 mm long, laterally concave, apically constricted, opening by short apical slits; **pistillode** ± wheel-shaped, lobes 5, bifurcate, glabrous, dark gray. **Female inflorescence** flowers solitary, from caducous bract scar axils near the base of young stems. **Fruiting pedicels** 7–12 mm long, stout, very minutely hirtellous. **Fruiting calyx** 5-lobed; **fruiting calyx tube** 3.5–4 mm long, explanate to reflexed; **fruiting sepals** accrescent, coriaceous,

arcuate-reflexed to spreading, 7–25 mm long, 7–13 mm wide, oblong, narrowly triangular or ovate, apex usually ascending to incurved, sometimes glaucous-pruinose to scintillant. **Fruit** berry, 3–5.5 cm long, up to 4.7 cm wide, subglobose, *locules* 8–10; **mesocarp** fleshy, yellow-orange in dried specimens; **hypodermis** thick and stony; **epidermis** smooth to bullate, shiny in living material, green to brown or black, herbarium material reddish-brown to dark-brown, immature fruits sometimes atropurpureous. **Seeds** not seen in available material (seeds orangish in photograph in Sánchez-Coello 2002 from Conde 2000), described by Pacheco (1981) as brownish to grayish, shiny, very rugose, and with a prominent raphe.

Additional specimens examined. **MÉXICO. San Luis Potosi. Mpio. Tamazunchale:** Tamazunchale, [21° 16'N, 98° 47'W, 153 m], 24 Jul 1937, *M.T. Edwards 670* (MO, US). **Veracruz. Mpio. Alto Lucero:** Cruz Blanca, 19° 46'N, 96° 40'W, 900 m, 30 Apr 1980, *L. Pacheco & J.I. Calzada 23 & 24* (XAL); same locality, 19 Sep 1979, *L. Pacheco & J.I. Calzada 18* (XAL); Cruz Blanca, 19° 40'N, 96° 50'W, [900 m], 25 May 1998, *Tono Vázquez 98-045* (UCR). **Mpio. Chiconquiaco:** Cañada del Huerfano, 19° 49'N, 96° 48'W, [900–1200 m], 10 Jul 1966, *A. Gomez-Pompa 1602* (XAL). **Mpio. Martinez de la Torre:** Malaupan [Santa Ana Maloapan, 20° 04'N, 97° 04'W], 100 m, 15 Mar 1978, *F. Ventura A. 15078* (IEB, XAL). **Mpio. Tantima:** Sierra de Tantima, 21° 17'N, 97° 51'W, 740 m, 23 Aug 1979, *J.I. Calzada 5550* (XAL). **Mpio. Tepetzintla:** Sierra de la Peña Blanca, Sierra de Tantima, [21° 13'N, 97° 55'W, ± 700 m], 21 Sep 1989, *P. Zamora C. et al. 1217* (XAL); San José de Copaltitla al NE de Tepetzintla, 21° 12'N, 97° 52'W, 350 m, 28 Aug 1981, *G. Castillo C. & A. Benavides M. 2265* (XAL); Cerro de Mixtepec, Sierra de Tantima, 21° 18'N, 97° 50'W, 1000 m, 17 May 1988, *J. Becerra Z. 83* (XAL).

Distribution and Ecology.—The only known collection of this taxon made outside of the state of Veracruz is from Tamazunchale, San Luis Potosi. This 1937 collection (*M.T. Edwards 670*) is the earliest one of the species known to us. Tamazunchale is at 153 m, a low elevation based on the literature (e.g. Pacheco 1981). In northern Veracruz, this species occurs in the Sierra de Tantima. In central Veracruz, occurrences are in the Sierra de Chiconquiaco, the lowlands of its northern base, and the Misantla region. Populations in northern Veracruz are in isolated cloud forest patches. In central Veracruz, collection sites have been characterized as forested escarpments near pasture (Sosa et al. 1998), cloud forest, and deciduous forest (Pacheco 1981) at 750–1000 m. It seems not to be widely realized that this taxon also occurs at lower elevations at 100–300 m. Low elevation occurrences are associated with tropical evergreen forest with *Quercus*. In this community, they are known to flower during March. This species is considered to be in danger of extinction (Sánchez-Coello 2002).

Ethnobotany.—The tree is called 'granadilla' in the Sierra de Tantima region of northern Veracruz where it is considered edible (*G. Castillo C. & A. Benavides M. 2265*). The name 'sapote prieto', is indicated on the collection from Tamazunchale, San Luis Potosi.

2. Diospyros gomeziorum M.C. Provance & A.C. Sanders, sp. nov. **(Fig. 2e)**. TYPE: MÉXICO. QUERETARO: Mpio. Jalpan de Serra, 5–6 km al NW de San Juan de los Dúran, El Arroyo, 21.48°N, 99.12°W, escaso, bosque de pino-encino, cedro blanco, orilla de arroyo, cañada, 1500–1600 m, 21 Aug 1991 (fr), *Benito Servín 1274* (HOLOTYPE: IEB-150586).

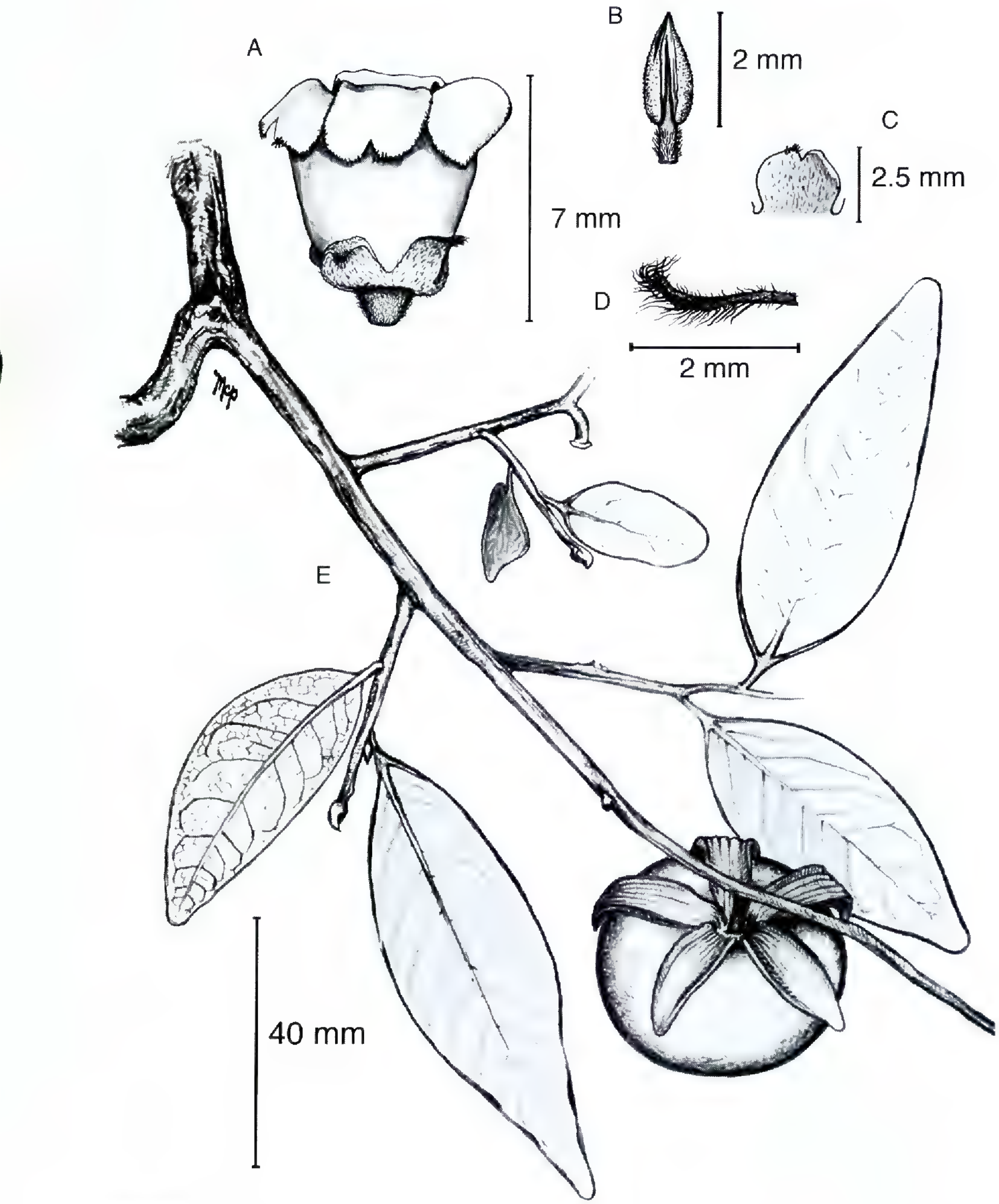


FIG. 2. **A–E.** *Diospyros gomeziorum* M.C. Provance & A.C. Sanders, sp. nov. **A.** Staminate flower. **B.** Typical anther. **C.** Adaxial surface of staminate petal lobe. **D.** Lateral view of staminate inflorescence bract. **E.** Fruiting branch. A–C. Based on *R. Fernández N. 2829*. D. Based on *Hiram Rubio 1520*. E. Based on *Benito Servín 1274*.

Arbor frutexve usque ad 20 m altus, *D. riojae* Gómez-Pompa similis sed differt margine folii a pagina adaxiali usque ad paginam abaxialem exter obliquantibus; cellulis epidermalibus paginae laminae adaxialis non amplificatis, sinc conspicue incrassatis parietibus cellularum anticlinalibus; foliis saepe copiose glaucipruinosis; calyce fructifero effuso et cum apicibus sepalorum ascendentibus; pedicellis fructiferis non crassis.

Trees or shrubs to 20 m tall, facultatively deciduous; **trunk** reported to 12 cm diameter for a 5-6 m tree (*Servín 1274*) and 20 cm in diameter for a 4 m tree (*R. Fernández N. 2459*), erect, longitudinally fissured, *bark* gray, reportedly shiny; **aged stems** angular, *bark* verrucose, scarred, short-fissured, cinereous, *stem wood* yellow to yellow-orange; **2nd–3rd year stems** angular to subterete, sometimes hirtellous, ± half-netted, the outer epidermal layer gray, tawny or reddish-brown, the lower layer cream to orangish; lenticels protruding, sometimes 2–3 mm long; **current year's stems** subterete, smooth to striate, densely hirtellous, reddish-brown, puncticulate. **Petioles** stout, often thicker than wide, 2–5(–8) mm long, glabrous to minutely erect hairy to deltoid scaly, rounded to ruminate below, usually glistening, dark brown to olive green, narrowly channeled, flat or barely raised, furfuraceous-glandular, ascending ciliolate on margin, yellow-green to olive above. **Leaves** alternate, simple, entire, pergamentaceous to chartaceous, sometimes subcoriaceous, lanceolate to ovate to elliptic, 6–11(–11.5) cm long, 2–4.8 cm wide, *apex* acute, obtuse or acuminate to a rounded point, *margin* beveled outward from upper surface at ± 45° to the lower surface, somewhat sharp, shiny, sparsely to moderately ciliolate, *base* acute to obtuse, decurrent onto petiole; **lower leaf surface** glabrous to sparsely subappressed pubescent, hairs black or reddish, most common near the base, midrib, and apex, surface shiny, green to olive, puncticulate; **upper leaf surface** glabrous, glaucous to pruinose-scintillant, localized or covering most of surface, but not on the beveled margin, granular-papillose, olive or pale blue-olive to dark-olive or dark blue-green, usually darker above than below, young leaves tend to be lighter above. **Venation** arcolanguid, granular-papillose, glaucous to pruinose-scintillant; **midrib** prominent below, glabrous to subappressed pubescent, hairs black, reddish-brown, or white, narrowly canaliculate above, sparsely to densely hirtellous to deltoid scaly, rarely glabrous, yellow-green; **2° venation** subprominent below, *lateral veins* (8–)11–13(–14) pairs; **3° venation** reticulate, obscure to prominent below, usually prominent above. **Laminar extrafloral nectaries** abaxial, minute, circular. **Male inflorescence** fascicles of 1–3(–5) flowers in leaf scar axils of previous year's growth, or one to several flowers at the base of new growth in scar axils of caducous bracts; **pedicels** 1–3 mm long, densely straight hairy, the hairs reddish, black, and white; **pedicel bracts** 2, 2–2.5 mm long, ± linear. **Male flowers** (4–)5(–6)-merous; **calyx** infundibuliform-campanulate, deeply lobed, interior glabrate or scantily minute white hairy, exterior sparsely minute deltoid scaly; **calyx tube** 1.5–2 mm long, 2.5–3 mm wide, sparsely subappressed puberulent; **sepals** lance-ovate to triangular, 2–7 mm long, 1–4

mm wide, exterior glabrous to pubescent basally, subappressed pubescent apically, the hairs glossy, black to reddish, simple and glandular, epidermis viscous; **corolla** urceolate-campanulate, white in living material; **corolla tube** 3–5.5 mm long, 3–6 mm wide, exterior densely pubescent, most hairs distally oriented, some hairs irregular, interior sparingly hirtellous, hairs sometimes erratically directed; **corolla lobes** (4–)5, spreading, oblate to squarish or widely obovate, often emarginate, 2–4 mm long, 2–3.5 mm wide, several short black hairs near the apex, interior sericeous. **Stamens** 20, equal to, or barely surpassing tube, most adnate to corolla, some inserted on the receptacle; **filaments** 0.3–0.8 mm long, ascending puberulent; **anthers** basifixed, oblong-ovate to ovate, 2 mm long, opening by short slits near apex, rarely by complete lateral slits, granuliferous, apex acute or rounded and mucronulate; **pistillode** conspicuously wheel-shaped, short, wide, corrugate. **Female inflorescence** flowers solitary, cauline near the base of current season's growth, rarely from leaf scar axil of old growth (e.g. *Ferguson 15*), sometimes two opposite inflorescences, but two mature opposite fruit not seen. **Female flowers** not seen, but **styles** (4–)5 as remnants on mature fruit, appressed white puberulent. **Fruiting pedicels** (4–)5–8(–11) mm long, densely hirtellous. **Fruiting calyx** 5–6-lobed. **Fruiting calyx tube** 3–4 mm long; **fruiting sepals** accrescent, ± spreading, 19–20 mm long, 8–11 mm wide, lanceolate to narrowly elliptic or obovate, glabrous to sparsely appressed hairy, apices rounded, sometimes ascending, surfaces often bluish-white glaucous, non-glaucous areas tawny, puncticulate. **Fruit** berry, subglobose to slightly obovoid, 3 cm long, 3–4.5 cm in diameter, green when immature, turning black (and then presumably ripe), atropurpureous in dried specimens, *locules* 10; **mesocarp** orange when dry; **hypodermis** thin, not very stony, often broadly rippled in specimens; **epidermis** orange-peel-textured, scintillant, glaucous-pruinose. **Seeds** 16–19 mm long, 9–10 mm wide, rugose, shiny, light brown.

PARATYPES: **MÉXICO. Hidalgo. Mpio. Meztitlán:** Barranca de Meztitlán, 9 km al NE de Mesquititlán a lo largo de una cañada, 20.74°N, 98.98°W, 2200 m, 3 May 1975, *F.G. Medrano et al. 7932* (SD, US, XAL). **Queretaro. Mpio Arroyo Seco:** 2 km al W de El Jardín, 21° 25' 24"N, 99° 41' 42"W, 1380 m, 4 Jul 1989, *E. Carranza 1852* (IEB). **Mpio. Jalpan de Serra:** 2–3 km al Poniente de San Isidrio, La Parada, 21° 30.5'N, 99° 10'W, 1300 m, 14 May 1990, *Benito Servín 206* (CIIDIR, IEB); 2–3 km al S de La Parada, 21° 32.3'N, 99° 10'W, 1200 m, 26 Mar 1990, *Benito Servín 58* (IEB); 6–7 km al Oriente de La Parada, 21° 30.5'N, 99° 6.8'W, 1400 m, 5 Apr 1990, *Benito Servín 96* (IEB); 2–3 km al N de La Parada, 21° 32.3'N, 99° 10'W, 1100 m, 13 Aug 1990, *Benito Servín 412* (IEB); ± 2 km al W de La Parada, Cuesta de los Lirios, 21° 30.5'N, 99° 11.2'W, 1180–1250 m, 13 Mar 1990, *E. Carranza 2392* (CAS, IEB). **Mpio. Colón:** cerca vado río Colón, 20° 48'N, 100° 03'W, 1900 m, 2 Apr 1982, *Elizabeth Arqüelles 1761* (DES). **Mpio. Pinal de Amoles:** 1 km S de Escanelilla, sobre la carretera a Pinal de Amoles, 21° 9'N, 99° 33'W, 1250 m, 18 May 1987, *J. Rzedowski 43398* (HUAA, IEB); + 4 km al SE de Santa Agueda, 21° 14' 30"N, 99° 37' 54"W, 1190 m, 18 Apr 1989, *E. Carranza 1635* (IEB); 3 km al S de Escanelilla, 21° 10.2'N, 99° 34'W, 1100 m, 19 Mar 1985, *R. Fernández N. 2829* (US); same location, 30 Jul 1984, *R. Fernández N. 2459* (IEB). **Mpio. Landa de Matamoros:** 1.5 km al SW de El Naranjo, 21° 01' 18"N, 99° 27' 42"W, 900 m, 10 Mar 1990, *Hiram Rubio 1542* (IEB); 1 km al Poniente de El Cerro de La Palma, 21° 12' 28"N, 99° 04' 32"W, 1500 m, 2 Mar 1990, *Hiram Rubio 1520* (IEB); cerca de Tres Lagunas, 21° 19' 36"N, 99° 12' 12"W, 1700 m, 22 Jun 1988, *J.*

Rzedowski 46695 (IEB); 2 km al Norte de Neblinas, 21° 13' 58"N, 99° 06' 18"W, 1060 m, 29 Sep 1988, *Hiram Rubio 185* (IEB); El Humo, 2 km a l'Ouest d'El Humo, 21° 18'N, 99° 05'W, 1320 m, 1 Oct 1994, *J.N. Labat & E. Carranza 2562* (IEB); 2 km al SE de El Humo, 21° 13' 55"N, 99° 06' 15"W, 1100 m, 7 Jun 1989, *Hiram Rubio 775* (HUAA, IEB); 2.5 km NE de El Humo, [21° 18'N, 99° 05'W], 1000 m, 11 Aug 1990, *Hiram Rubio 1865* (IEB); 1.5 km SE de El Naranjo, 21° 01' 18"N, 99° 27' 42"W, 1000 m, 25 Jun 1990, *Hiram Rubio 1746* (IEB); 4–5 km al S de Tres Lagunas, 21° 19' 33"N, 99° 12' 12"W, 1820 m, 3 Mar 1990, *E. Carranza 2359* (HUAA, IEB); El Calvario, 1 km al Poniente de El Aguacate, 21° 16' 06", 99° 14' 42", 1620 m, 26 Jun 1989, *Hiram Rubio 838* (IEB); ± 8 km de desviación, camino Tres Lagunas, 21° 19' 35"N, 99° 06' 15"W, 1900 m, 7 Nov 1988, *E. Carranza 1144* (IEB); 2 km al SE de Neblinas, 21° 15'N, 99° 03' 12"W, 900 m, 23 Jun 1989, *Hiram Rubio 826* (IEB). **San Luis Potosi. Mpio. Rayon:** 3.5 mi by road S of km 81.5 on hwy 70 W of Valles at microwave tower, [± 21° 53'N, 99° 30'W], 1340 m, 23 May 1981, *George Ferguson 15* (UTEP). **Tamaulipas. Mpio. Gómez Farias:** Rancho del Cielo, a 11 km de Gómez Farias, [23° 04'N, 99° 12'W], 1110 m, 22 Sep 1974, *F.G. Medrano 7416* (ARIZ); Rancho del Cielo, La Sierra de Gómez Farias, 1100 m, 1 May 1982, *H. Narave F. & T. Dent 134* (XAL); Rancho El Cielo, F. Harrison's place, E ridge of the Sierra Cucharas, 1200 m, 23 Aug 1950, *E. Hernández X. & F. Harrison X-5861* (CHAPA).

Distribution and Ecology.—This species occurs in the Sierra Madre Oriental, including the Sierra Cucharas, just north of Gomez Farias in southwest Tamaulipas, mountainous regions southwest of Tamasopo in southeast San Luis Potosi, northeast Queretaro, and Barranca de Meztitlán in eastern Hidalgo. Collections are from a variety of vegetation types at elevations between 900 and 2200 m. More material, by far, has been collected in the state of Queretaro than any other state. In Queretaro, it has been described as abundant in pine-oak forest, oak forest, oak forest with *Liquidambar*, and *Tilia* forests. Other settings in which it has been reported but described as scarce include gallery forests with *Platanus*, and canyons with *bosque mesofilo de montaña* (± cloud forest). An unusual association occurs in Hidalgo, where it was described as very abundant in a canyon with *matorral espinoso* and *matorral crasicaule* at 2200 m (*F.G. Medrano et al. 7932*). The five male flowering collections we examined were all taken in March. Some of these specimens were just leafing out at the time. The fruits ripen between September and early November.

Ethnobotany.—Queretaro: 'zapote prieto' (*Rubio 1746*), 'zapote del monte' (*Servín 206*), zapotillo (Carranza 2000).

Etymology.—The epithet is intended to honor both Arturo Gomez-Pompa, who discovered and described *Diospyros riojae*, and has also been a great inspiration to our work on Latin American *Diospyros*, and also the late J. 'Carmelo' Gomez, who assisted the first author in the field on many occasions, and was very knowledgeable on local plant use in the Sierra Tlachichila, Zacatecas.

Collections of *D. gomeziorum* have often been confused with *D. riojae*. A conspicuous feature that differentiates *D. gomeziorum* from *D. riojae* is the leaf margin, which is beveled outward from the upper to the lower surface at about 45° in *D. gomeziorum*. The margin formed tends to be sharp, shinier, and greener, while that in *D. riojae* is thick, not as shiny, and a paler green. Other differences include the upper leaf surface, which is often copiously glaucous-pruinose in *D. gomeziorum*, while typically only the abaxial leaf surface is slightly prui-

nose-scintillant in *D. riojae*. The epidermal cells of the upper leaf surface in *D. riojae* are large, with thickened anticlinal walls, a feature absent in *D. gomeziorum*. Leaf shape in *D. gomeziorum* ranges from elliptical to lance-ovate or ovate, while the leaves of *D. riojae* often tend to be oblong or obovate. However, this character overlaps, since both taxa may have elliptical leaves. In fruiting collections, the shorter, less stout, fruiting pedicels, the thinner, less sclerenchymatous fruit wall, and the glaucous-pruinose to scintillant fruit distinguish *D. gomeziorum*. The pedicel bracteoles of the male inflorescence in *D. gomeziorum* are twice as long as those in *D. riojae*, and are nearly folded lengthwise (navicular). The anthers in *D. gomeziorum* are minutely granular, lacking the apical constriction and smooth texture seen in *D. riojae*.

Carranza (2000) described male flowers of this species (as *D. riojae*) as cymose. We did not find cymes in material referable to either species. Developmentally, the inflorescences may be related to cymes, but, they appear to be fascicles. Some flowers may appear to be in dense terminal clusters (e.g., *H. Rubio 1542*). However, this appearance is superficial, since small terminal shoot apices can be found, although sometimes only with difficulty.

3. Diospyros conzattii Standl., J. Wash. Acad. Sci. 12(17):399. 1922. **(Fig. 3)**. TYPE: MEXICO. OAXACA: Distrito de Pochutla, Cerro Espino, Cafetal San Rafael, 24 Apr 1917 (fr), *C. Conzatti 3167* (HOLOTYPE: US-1014759 not seen; ISOTYPES: MO-879066! (in sched. 1100 m, with *Reko & Makrinus*), MO-1039787!, fragment US-892600! (in sched. 900 m, with *Reko & Makrinus*).

Trees or shrubs, 8–10 m tall, probably facultatively deciduous, trunk not reported; **aged stems** subterete to angular, *bark* verrucose, fissured, gray, *stemwood* off-white to yellowish or pale orange; **2nd–3rd year stems** angular to subterete, *bark* rimose, epidermis glabrous to sparsely hirtellous, sometimes pulverulent, sparingly clavate glandular hairy, densely lenticellate, puncticulate, chestnut to tawny, becoming silvery gray; **current year's stems** quadrangular, finely sulcate, glabrate to hirtellous, sometimes sparsely strigillose, the hairs off-white to brown, the epidermis shiny, viscous, olive to nearly black. **Petioles** usually thin, sometimes flexuous, 5–8 mm long, pale green to green-brown, rounded below, glabrous to appressed puberulent, conspicuously winged part way above, the wings becoming vertically oriented and narrow along the petiole, petiole slightly convex and minutely V-grooved above, to widely flat-channeled, to 3-channeled (main channel raised and skirted by side channels formed by vertical wings), glabrous to erect puberulent, sometimes clavate glandular hairy, especially in young leaves. **Leaves** alternate, simple, entire, pergamentaceous to chartaceous, lanceolate to elliptic to ovate, 5–14(–14.7) cm long, (2.5–)3–5(–6) cm wide, immature leaves membranaceous, *apex* acuminate to an acutely or obtusely rounded point, *margins* flat to subrevolute, curved downward near the base of the leaf, thickened intramarginal zone seen when viewed abaxially, hyaline and minutely ciliolate in immature leaves, base acutely or obtusely

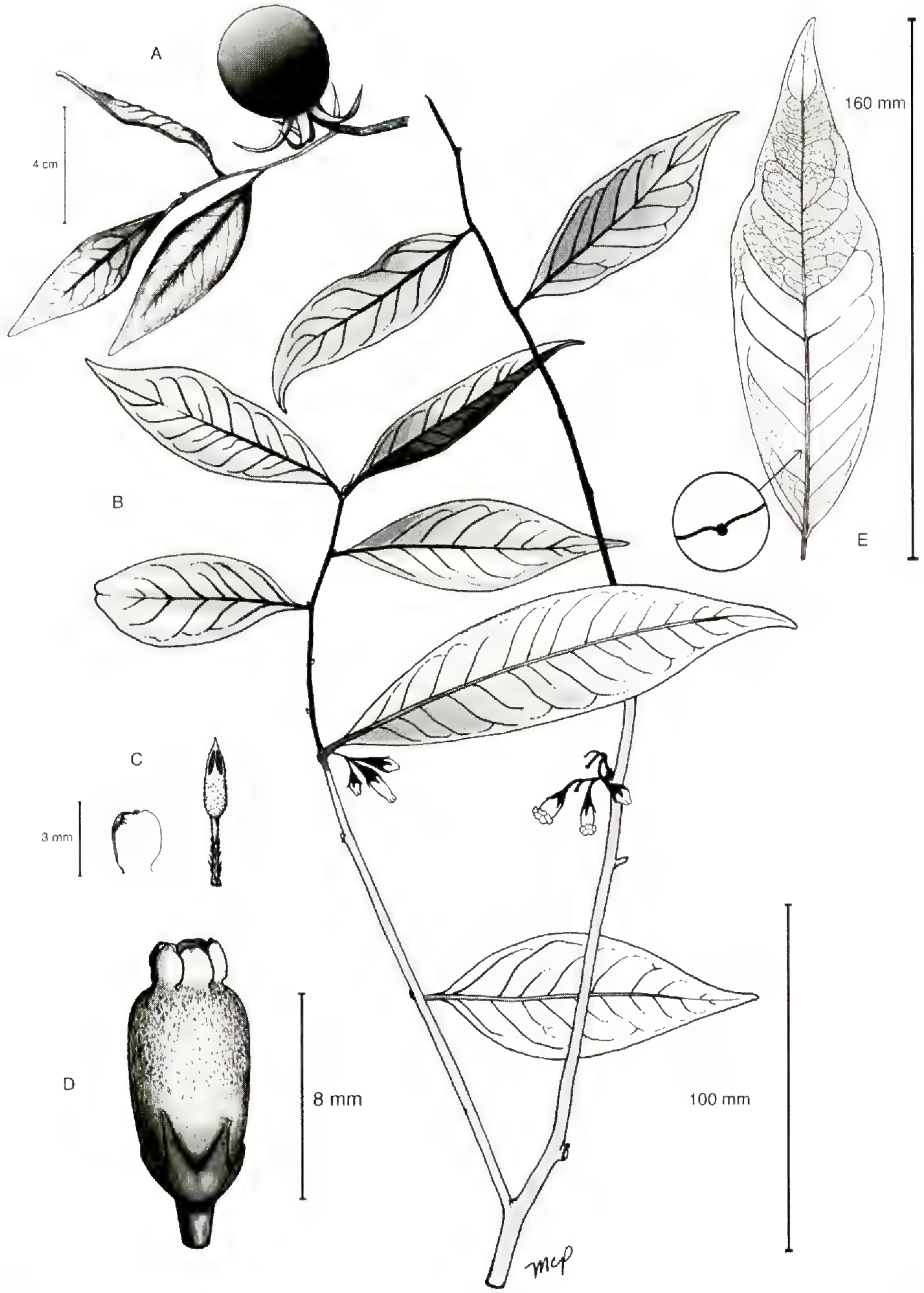


FIG. 3. **A–E.** *Diospyros conzattii* Standl. **A.** Fruiting branchlet. **B.** Staminate flowering branch. **C.** Adaxial surface of staminate petal lobe (left) and typical anther (right). **D.** Staminate flower. **E.** Adaxial surface of mature leaf (apex extrapolated) showing detail of several degrees of venation, and a lateral cross section of the leaf (outset detail). A. Based on *J.L. Martinez & A. Hernandez 1302*. B–E. Based on *F. Ventura A. 7131*.

rounded, sometimes cuneate, decurrent onto petiole, sometimes loosely recurved near the petiole; **lower leaf surface** usually glabrous, very rarely minutely white glandular hairy, puncticulate, dull, olive; **upper leaf surface** glabrous, glaucous, densely puncticulate, dull, olive. **Venation** arcolanguid; **midrib** very prominent below, slightly undercut, terete, glabrous, straw to light-green, weakly raised above, and then caniculate within the raised midrib, very sparsely minute erect hairy; **2°–3° venation** reticulate, veins narrow, raised below and above, *lateral veins* 9–14 pairs, 2° arches formed with superadjacent lateral veins typically obscure. **Laminar extrafloral nectaries** abaxial, conspicuous, round to oval, dark-red to black, often evenly spaced and near the midrib. **Male inflorescences** cymes, 1(–2) near the base of current year's stems, or (1–)2 leaf scar axils of the previous year's growth, 1–3-flowered, black to umber velutinous, sparsely covered with minute clavate glandular hairs; **peduncles** 4–6 mm long, velutinous, umber to dark brown; **pedicels** slender, 5–7 mm long, vestiture as in peduncles; **pedicel bracts** 1–2, alternate or opposite, narrowly oblong, 1 mm long, 0.8 mm wide, umber. **Male flowers** 5(–6)-merous; **male flowering calyx** funnelform, drying very dark-brown to black, glabrate to appressed-pubescent, coterminous with pedicel and uninterrupted; **male flowering calyx tube** 2–3 mm long, 1.5–2 mm wide; **sepals** 5, acute-triangular, 2–4 mm long, ciliolate, apically vermiform glandular hairy, sinuses rounded; **corolla** 5–6-lobed, long-urceolate, drying very dark-brown to black, reportedly whitish in life; **corolla tube** widest above middle, 7–8.5 mm long, 4–5 mm wide, abruptly constricted distally, exterior densely minute white puberulent, hair density ± increasing distally, interior sparsely white puberulent, the hairs concentrated in regions of filament attachment; **corolla lobes** quadrate to oval, 2–2.5 mm long, 1.5–2 mm wide, asymmetrical, apex obtuse-rounded, truncate, emarginate, or trifid, often with several short dark hairs, exterior densely minute white puberulent, interior inflexed at the distal right margin, left margin slightly involute, pubescent. **Stamens** 30, sometimes attached in pairs, adnate to corolla from midpoint to bottom of tube, sometimes inserted on the receptacle; **filaments** 3 mm long, minutely hairy; **anthers** basifixed, lanceo-apiculate, 3–3.5 mm long, opening by terminal pores or short lateral slits, connective minutely deltoid-scaly, *pistillode* minute, obturbinate, smooth, nearly unlobed, having a few smooth very small basal lobes, glabrous. **Female inflorescence** flowers solitary, cauline, at the junction of current and previous year's growth. **Fruiting pedicels** stout, (7–)12–15 mm long, glabrous to sparingly minute hirtellous. **Fruiting calyx** 5-lobed; **fruiting calyx tube** 3 mm long, explanate to campanulate, usually with a conspicuous enlarged basal region encircling the pedicel joint; **fruiting sepals** accrescent spreading to reflexed slightly, apices straight, coriaceous, narrowly to linearly triangular, 24–31 mm long, 5–8 mm wide, margins sometimes sharp edged, sometimes glaucous, glabrous, puncticulate. **Fruit** berry, depressed-globose slightly obovoid, up to 4 cm long, 4.5 cm in diameter, reportedly reddish (*Chazaro 3969*) or green (Standley

1922) when ripe, mostly atropurpureous in herbarium material. *Locules* 10–12; **mesocarp** reportedly black when ripe, usually orange in dried specimens; **hypodermis** 0.2–0.5 mm thick, stony; **epidermis** bullate, glaucous-scintillant, usually wrinkled when dry. **Seeds** 15–16 mm long, 11–12 mm wide, 5.5–9.5 mm thick, sculpture cerebriform, chestnut.

Additional material examined: **MÉXICO. Veracruz. Mpio. Calcahualco:** 4.2 km W of Escola, 19° 10'N, 97° 10'W, 2200 m, 12 Jan 1981 (fr), *M. Nee & G. Schatz 19777* (XAL). **Mpio. Chiconquiaco:** abajo de Vaqueria dirección Arroyo Colorado, 19° 46'N, 96° 45'W, 1650 m, 25 Oct 1988 (fr), *C. Gutierrez B. 3292* (XAL) & *3293* (XAL). **Mpio Coscomatepec:** 3 km al SE de la antigua Xicola, Cima del Cerro La Magdalena, 19° 06'N, 97° 04'W, 1900 m, 29 Apr 1987 (fr), *J.L. Martinez & A. Hernandez 1302* (XAL). **Mpio. Jalacingo:** El Cuizalín, ca. 19° 50'N, 97° 16'W[1], 1500[2] m, 22 May 1982 (pist. fl), *F. Ventura A. 7131* (IEB, MO, XAL). **Mpio. Tatatila:** camino de herradura de Tatatila a Escalone (o Puente Caballos), [± 19° 42'N, 97° 6'W, 1500 m], 14 Jan 1986 (fr), *M. Chazaro & Roberto Acosta 3969* (WIS, XAL). **Mpio. Tlacolulan:** Abajo del Saucal, dirección Agustin Melgar, 19° 45 N, 96° 57'W, 1180 m, 14 Aug 1990 (fr), *C. Gutierrez B. 4056* (XAL).

Distribution and Ecology.—The type locality is in the Pacific coastal ranges of the Sierra Madre del Sur, Oaxaca. It occurs there in dry tropical forest on coastal slopes (Anonymous 1927). According to Conzatti (in Standley 1922), the fruit is ripe in April. In Veracruz, occurrences are near Pico de Orizaba, the Sierra de Tezuitalan, and the Sierra de Chiconquiaco, between 920 and 2200 m altitude. It occurs on slopes with pine-oak woodland and Alnus, oak forests, and deciduous forests.

Ethnobotany.—Veracruz: 'zapotillo' (*C. Gutierrez B. 3292*). Oaxaca: 'zapote negro montés' (Standley 1922 [quoting Conzatti], and on US-892600), 'zapote negro silvestre' (*Conzatti 3167* [in his own handwriting]). The wood is considered valuable (Anonymous 1927 [paraphrasing Conzatti]).

Only one of the isotypes we examined, MO-879066, included a fruit. Unfortunately, the large atropurpureous fruit is in rather poor condition. However, upon close examination it was clear that the epidermis is bullate, glaucous, although tending towards brown in some areas. The fruit wall is thick and quite stony. A fragment packet attached to another type, MO-1039787, contains a spreading fruiting calyx tube bearing the basal 5 mm of one sepal, and much less of the base of another. The sepals appear to have been quite narrow, ca. 4–5 mm wide at the base and further narrowed distally. Characteristics seen in the fruit of *D. conzattii* collections from Veracruz are consistent with the characteristics found in the isotype. An enlarged region below the fruiting calyx encircling the pedicel joint is only seen in the Veracruz material, but not the isotype. At this point, we are unsure of its significance.

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[1]Coordinates based on F. Ventura A. collection of *Rhamnus capreaefolia* var. *capreaefolia* from Cuizalín, 22 June 1970 (LL) accessed through REMIB. www.conabio.gob.mx/remib_ingles/doctos/ remib_ing.htm .

[2]The label indicates the collection was made at 150 m. This seems to be a typographical error. The coordinates for Cuizalín are compatible with an elevation estimate of 1500 m.

4. Diospyros costaricensis M.C. Provance & A.C. Sanders, sp. nov. (**Fig. 4b, e**). TYPE: COSTA RICA. GUANACASTE. Cantón de Liberia: Parque Nacional de Guanacaste, Cordillera de Guanacaste, Cerro Cacao, Estación Cacao, 10° 55' 45"N, 85° 28' 15"W, 1100 m, 14 Jul 1991 (fr), *Carlos Chávez 569* (HOLOTYPE: MO-5316680!; ISOTYPES: "4 duplicates" indicated on label, but not seen by us).

Arbor *D. conzattii* Standl. similis sed anterides-faciente, usque ad 35 m alta et 1.5 m diametro; petiolis adaxiale fere negris; zona intermarginali laminae neque incrassata neque elevata in pagina abaxiali; costa glabra ad aurohirtella adaxiale, vadose (saepe late) concava, aut ab lateribus contiguis laminae longistrorsum crispanti in speciminibus exsiccatis.

Trees, probably facultatively deciduous, reportedly colonial, reportedly up to 35 m tall, and 1.5 m in diameter (*Espinoza 54*); **trunk** buttress-forming, channeled, smooth, greenish-black to greenish-brown, *slash* yellow and aromatic; **aged stems** somewhat angular, half-netted, black to gray above, lower layer beige to golden-brown, sometimes ± mottled, sometimes shallow-fissured, lenticellate; **2nd–3rd year stems** irregularly half-netted, beige beneath, black and grey above, hirtellous, pubescence sometimes persisting on three year old stems, lenticellate; **current year's stems** quadrangular, sulcate to minutely ridged, sparsely subappressed golden hairy, the hairs fine and ± straight, sparingly to very densely erect puberulent, dark-green to black, somewhat glandular, becoming lenticellate. **Petioles** usually thin, somewhat flexuous, 3–6.5 mm long, wings tapering gradually from the decurrent lamina, and twisting abruptly into a vertical orientation along the margin, glabrous to hirtellous below, rugose to invaginate, light olive to very dark brown, concave above, often minutely V-grooved, usually golden hirtellous, often glandular, epidermis often nearly black. **Leaves** alternate, simple, entire, chartaceous to subcoriaceous, cartilaginous, ovate to elliptic, rarely widely-obovate, 6.5–9.5(–10.2) cm long, 2.8–4(–5) cm wide, very often tattered around the margins, wrinkled, *apex* usually asymmetric, tapering to an obtusely rounded tip, *margin* curved under near the base of the leaf, *base* mostly obtuse and tardily abrupt-acuminate, sometimes acute, long decurrent onto the petiole; **lower leaf surface** sparsely appressed puberulent, puncticulate, sometimes clavate glandular hairy near base, dull, brown to brown-green; **upper leaf surface** glabrous, very rarely glaucous-scintillant, papillose, puncticulate, brown-green. **Venation** brochidodromous; **midrib** prominent below, glabrous to sparsely appressed puberulent or hirtellous, epidermis green to brown-green, shallowly concave above, glabrous to golden hirtellous, sometimes partly shrouded by the lamina, then canaliculate and hairs crisscrossing, epidermis of basal half often black, otherwise greenish; **2° venation** fine below, usually prominent, *lateral veins* 9–12 pairs, forming definite 2° arches with superadjacent lateral veins, arch apices 3 or more mm from the margin, venation tending to be obscure above, but variable; **3°–4° venation** reticulated below, fine, usually apparent, but varying from obscure to prominent. **Laminar extrafloral nectaries** often up to 30, sometimes more, scattered on the abaxial side of the lamina, minute, peripherally rimmed with a narrow band

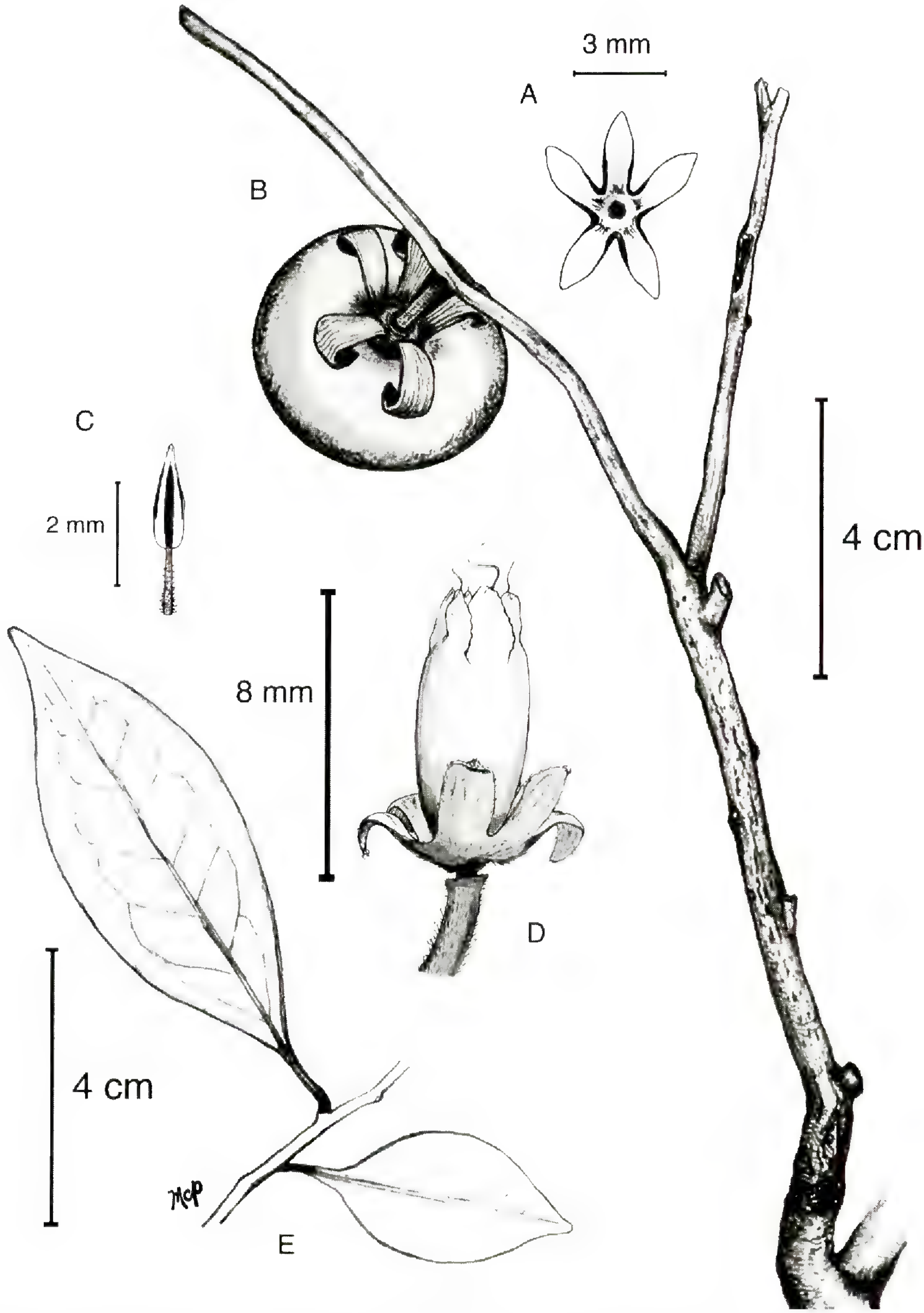


FIG. 4. **A–E.** *Diospyros costaricensis* M.C. Provance & A.C. Sanders, sp. nov. **A.** Adaxial view of staminate male calyx with corolla removed. **B.** Fruiting branch. **C.** Typical stamen. **D.** Staminate flower. **E.** Stem with leaves. A, C, and D. Based on *Zobeida Fuentes, N. Zamora & Eduardo Lépiz 248*. B and E. Based on *Carlos Chávez 569*.

of raised tissue. **Male inflorescence** cymes, 2–3-flowered, 1–2 cymes per axil, from growth of the previous year, or from the base of new growth, densely subulate puberulent; **peduncles** up to 4 mm long, sparsely to densely pubescent to strigose with light brown to black hairs, epidermis dark brown; **pedicels** 0.5–3.5 mm long, vestiture and epidermis as in peduncles, *pedicel bracts* rarely persisting in herbarium material, 0.3–1 mm long, deltoid, densely hairy, the hairs dark-brown and straight. **Male flowers** 5-merous; **calyx** infundibuliform, exterior short-appressed gold to white puberulent, sometimes with clavate glandular hairs, epidermis dark brown; **calyx tube** 0.8–1.3 mm long, interior with ring of straight appressed white hairs; **sepals** usually erect, rarely slightly recurved, 2–3.5 mm long, 0.8–1.5 mm wide, interior glabrous to glandular setulose, exterior pubescent, often densely so at the apex, the hairs wavy and amber, appearing glandular; **corolla** long-urceolate; **corolla tube** 3.5–7.5 mm long, 3 mm wide, interior lower-third of tube short golden pubescent, hairs ± erratically directed, exterior evenly and densely short appressed to ascending golden hairy, also clavate glandular hairy; **corolla lobes** 5, quadrate to oval, 2–2.8 mm long, 1.2–2.5 mm wide; *apex* sometimes bearing a long flagellate trichome, interior right margins involute, interior glabrous, exterior appressed to ascending white puberulent, the left side of lobe densely appressed fine puberulent, sometimes with several minute black hairs near the apex. **Stamens** 17–19, adnate at various levels at and below the basal third of the corolla; **filaments** 1–1.5 mm long, narrowed distally, glabrous to densely erect hispidulous; **anthers** basifixed, 2.3–2.5 mm long, several minute hairs at the apex, surface light-yellow apically, opening by short lateral slits confined to the distal half to two-thirds of the anther, sometimes opening by a complete lateral slit, *pistillode* ± sub-conical, slightly wavy peripherally, ± 8 long straight hairs originating from the central apex, otherwise glabrous. **Female inflorescence** flowers solitary in leaf scar axils of 2nd year stems, or cauline at junction of previous and current growth. **Fruiting pedicels** stout, 3–18 mm long, sparsely hirtellous, reddish-gold, and gray, lenticellate. **Fruiting calyx** 5-lobed, sinuses acute; **fruiting calyx tube** explanate, sparsely appressed puberulent, scintillant, ± 3.5 mm long; **fruiting sepals** accrescent, coriaceous, lorate to lanceolate, (16–)22 mm long, (5–)6–8(–9) mm wide, spreading to moderately reflexed, apex straight to quite incurved, puncticulate, shiny, golden brown, sparingly scintillant basally. **Fruit** berry, sometimes pendulant, depressed-globose, 2.5 cm tall, 4 cm wide, reportedly green in living material, dull, atropurpureus to dark-brown in herbarium material, *locules* 10; **mesocarp** reportedly yellow in living immature fruits, dark orange in herbarium material; **hypodermis** ± 0.5 mm thick, stony, not wrinkling in herbarium material; **epidermis** bullate, glaucous to pruinose-scintillant, either locally or over most of the fruit. **Seeds** not seen.

PARATYPES: **Costa Rica. Guanacaste. Cantón de Liberia:** Parque Nacional de Guanacaste, Estación Cacao, 10° 55' 45"N, 85° 28' 15"W, 1100 m, 24 Nov 1990, *R. Espinoza 54* (K, MO); Cordillera de Guanacaste,

Estación Cacao, sendero a Estación Maritza, 10° 55' 43"N, 85° 28' 10"W, 1100 m, 15 Jul 1996, *José González et al. 1108* (K). **Cantón de La Cruz:** Parque Nacional de Guanacaste, Cordillera de Guanacaste, V. Orosí, Sector Orosí (antes Maritza), sendero Casa Fram. 10° 57' 40"N, 85° 29' 45'W, 600 m, 13 Jul 1994, *José González et al. 301* (MO [2 accessions]). **Puntarenas. Cantón de Puntarenas:** Reserva Biológica, Monteverde, Cordillera de Tilarán, Altos de San Luis, Los Leitones, 10° 17' 25"N, 84° 48' 10"W, 1200 m, 4 Sep 1991, *E. Bello 4014* (MO); sendero a la Catarata, por el río, sendero Miguel Leitón, 10° 16' 20"N, 84° 49' 30"W, 1100 m, 11 Mar 1993, *Zobeida Fuentes 248* (K, MO).

Distribution and Ecology.—As far as known, this tree is endemic to northwestern Costa Rica, where it occurs in the Cordillera de Tilarán and the Cordillera de Guanacaste, between 600 and 1200 m in elevation. Details concerning associated vegetation are mostly lacking on the collections from the Cordillera de Guanacaste, a drier and more seasonal mountain range than the Cordillera de Tilarán (Hammel et al. 2004). This species could be associated with deciduous forests of the region. The collections from Puntarenas come from the Pacific side of the Cordillera de Tilarán. Label data from one of the collections, *Bello 4014*, indicates that the tree was growing in *charral*, or young secondary forest (Kleinn et al. 2002). The other collection does not provide details about the associated vegetation. In a broad sense, the region of the occurrences in Puntarenas has been mapped as Costa Rican seasonal moist forests. These are deciduous forests that obtain 90% of their annual precipitation, (± 1500 mm total), during the months of April through October (World Wildlife Fund 2001). The formation of new leaves and male flowers apparently occur during March (only one flowering collection was examined).

Ethnobotany.—Known by the common name 'guacalillo' in Puntarenas, Costa Rica (*Fuentes 248*).

Etymology.—The epithet refers to the only country in which the species is currently known to occur.

This species is different from *D. conzattii* in several respects. First, it is a buttress-forming tree attaining 35 m in height; this is quite exceptional among *Diospyros* from Central America and Mexico. *Diospyros conzattii* is not known to reach over 10 m in height. The abaxial leaf venation is conspicuously brochidodromous, the lateral veins forming well defined secondary arches with the superadjacent lateral veins. Another interesting difference involves the distance from the outer-perimeter of secondary arches to the leaf margin, which is usually around 3–6 mm at about mid-leaf. This distance is 1–3 mm in *D. conzattii*. The marginal loops of *D. conzattii* often become difficult, but not impossible, to discern, hence the aforementioned distance is measurable. Some other vegetative differences useful for separating these species include yellowish to orange hairs on the adaxial midrib, and the converging adaxial lamina along the depressed midrib in *D. costaricensis*. The inflorescences of *D. conzattii* and *D. costaricensis* are clearly cymes, with peduncles around 6 mm and 4 mm long respectively.

5. Diospyros tuxtlensis M.C. Provance & A.C. Sanders, sp. nov. (**Fig. 5**). TYPE: MEXICO. VERACRUZ: Mpio. San Andrés Tuxtla, borde de la cima del Cerro Mastagaga, al N del Ejido Ruíz Cortinez, Sierra de los Tuxlas, 30 May 1985, *J.I. Calzada 11855* (HOLOTYPE: IEB-48870; ISOTYPE: XAL).

Arbor usque ad 10 m alta, *D. riojae* Gómez-Pompa similis sed differt foliis ellipticis et non glauciis, marginibus non crassis et inter paginas oppositas rotundatis; pedicellis abaxiale atropurpureis; sepalis fructiferis 26–40 mm longis, reflexissimis et com apicibus rectis; pedicellis fructiferis 14 mm longis.

Trees 8-10 m tall, probably facultatively deciduous; **aged stems** terete to subterete, ± glabrous, half-netted to squamose, dark-brown to grey-brown with beige, short-fissured *stem wood* yellowish to orange-brown; **2nd–3rd year stems** angular to subterete, glabrous, sulcate to shallow-fissured or half-netted, in combinations of dark-brown, gray, and orange-brown; **current year's stems** angular, smooth to finely sulcate, very cream to grey, shiny, lenticellate, glabrous to densely minute hirtellous, appressed off-white puberulent near apex, puncticulate. **Petioles** 4–7 mm long, glabrous, flat to slightly concave above, golden-brown, below widely rounded, glaucous-scintillant, dark-purple. **Leaves** alternate, simple, entire, pergamentaceous to chartaceous, ± elliptic, 8–15 cm long, 3–5(–5.8) cm wide, widest at or just above the middle, both sides very sparsely scintillant, but leaf surface dull golden-brown to bronze between individual scintillae, *apex* usually acuminate, the acumen long, narrow, obtusely rounded at the tip, *margin* flat with slight intramarginal thickening, *base* acuminate to attenuate, decurrent onto petiole; **lower leaf surface** sometimes sparingly appressed puberulent near base and midrib, conspicuously puncticulate; **upper leaf surface** glabrous, papillose. **Venation** arcolanguid to brochidodromous; **midrib** conspicuously flat and wide below, sulcate, purplish basally, becoming orange-red to golden-brown and somewhat keeled apically, sometimes sparsely appressed puberulent, glaucous, shallowly concave above, glabrous, not darkened; **2° venation** raised above, obscure, *lateral veins* 8–9 pairs, shiny, chartreuse to golden-brown and conspicuous; **3° venation** obscure below, granular-papillose, apparent above. **Laminar extrafloral nectaries** abaxial, common, sometimes along 2° veins, rimmed with the same bright color seen in 2° veins **Male inflorescence** unknown. **Female inflorescence** flowers solitary, emerging at the junction of old and new growth. **Fruiting pedicels** stout, 14 mm long, 3 mm wide, wavy-rugose, minutely fissured, lenticellate, black and tan mottled. **Fruiting calyx** with lobes and distal portion of tube strongly reflexed, sinuses rounded; **fruiting calyx tube** exterior sparsely appressed puberulent; **fruiting sepals** 5, very accrescent, 26–40 mm long, 7.5–11 mm wide, ovate to widely lanceolate, narrowed basally, apex acutely pointed, sometimes rounded, sepals glabrous, golden-brown, sepal nerves distinct. **Fruit** berry, depressed-globose, up to 4 cm tall, 4.5 cm in wide, atropurpureous, number of locules indiscernible; **mesocarp** dark-brown in live material and in immature fruits of herbarium material; **hypodermis** ± 0.5 mm thick, sclereidic; **epidermis**



FIG. 5. *Diospyros tuxtlensis* M.C. Provance & A.C. Sanders, sp. nov. Fruiting branch. Based on *J.I. Calzada 11855*.

glaucous-scintillant, wrinkled. **Seeds** immature, sizes indiscernible (broken seeds only), dark reddish brown, granulate to minutely ruminate (sensu Stearn 2000, fig. 38).

PARATYPES: **Mexico. Veracruz. Mpio. San Andrés Tuxtla:** senda para el Cerro Baxin, al N de San Andrés Tuxtla, Sierra de Los Tuxtlas, 6 Mar 1985, *J.I. Calzada 11929* (IEB, XAL). **Mpio. Soteapan:** Ejido Santa Marta camino a la Ventana, 18° 22'N, 94° 54'W, 920 m, 19 Sep 1986, *R. Acosta P. & C. González R. 1312* (LSU, XAL).

Distribution and Ecology.—Apparently endemic to the Sierra de Los Tuxtlas,

Veracruz, Mexico. Only one elevation recorded, 920 m (*R. Acosta P. & C. González R. 1312*). The associated vegetation types for the known collections have included primary selva mediana perennifolia, selva baja perennifolia, and deciduous forest. It was considered common in selva baja perennifolia with elements of deciduous forest (*Calzada 11855*).

Ethnobotany.—A common name has not been reported, but since the fruits are likely to be edible, the species may be well-known to local residents. The species may eventually be found as a conserved tree near homes or pastures.

Etymology.—The epithet refers to Sierra de Los Tuxlas, Veracruz, Mexico, from where the only collections of this species have been made.

SPECIES OF UNCERTAIN STATUS

Diospyros pergamentacea Lundell, Contr. Univ. Michigan Herb. 7:44. 1942. TYPE. MEXICO. CHIAPAS: Pico de Loro, near Escuintla, in advanced forest, 2200 m, 25 Jun 1941, *Eizi Matuda 4278* (HOLOTYPE: MICH not seen; ISOTYPES: photo A!, photo CAS! (sterile), photo F!, IT not seen, photo LL-372460!, MO-1213673!, US-1849013!).

A redescription of this taxon did not seem appropriate, given that there are no new specimens. We do not think we can add much to the work of Lundell. Overall, this species looks quite similar to *D. conzattii*, with which some authors have considered it conspecific[3]. This species is known only from the type specimen, collected on Pico de Loro, near Escuintla, Chiapas. The petioles are very long and flexuous, reported to be up to 15 mm long by Lundell (1942). There also seem to be differences in the sepals, they being strongly reflexed, and having a shape that is suggestive of some populations of *D. rosei* sensu lato. In fact, these differences are significant enough that we are not entirely convinced that it is synonymous with *D. conzattii*. The leaves of the isotypes we examined had a thin coating of clear glue on much of their surface, which may obscure some characters. We recommend re-evaluating the taxonomic status of this taxon when additional material from the Chiapas-Guatemala borderland becomes available. For the time being, we do not recommend reduction to synonymy with *D. conzattii*.

DISCUSSION

Neither the holotype nor the two isotypes of *D. riojae* were available for a first-hand examination. Unfortunately, there are no paratypes for *D. riojae*, *D. conzattii*, or *D. pergamentacea*. Microfiche of an isotype and the detailed description of *D. riojae* by Gomez-Pompa (1964) were valuable in completing this paper. The original description made use of tables and text in contrasting differences between *D. riojae* and *D. conzattii*. Additionally, it was supplemented

[3]For example: A. Gomez-Pompa (1964); F. White in 1968 and C. Whitefoord & S. Knapp in 1996, in both cases by annotation of the isotypes.

with an illustration prepared from the original collection (Gomez-Pompa, pers. comm.). The illustration is consistent with the type description, and the isotype at US, and in accordance with the *Code*, Article 9.2: Note 2 (Greuter et al. 2000), the illustration in the protologue represents original material.

Because fruiting *D. riojae* material keys to *D. conzattii* in Standley's treatment of *Diospyros* of Mexico (1924), Gomez-Pompa (1964) provided a table of leaf and fruit characters that could be used to separate these taxa. Admittedly, some of these characters overlap to some degree. When it is considered that Gomez-Pompa had one fruiting collection of *D. riojae*, one fruiting collection of *D. pergamentacea*, and probably only one collection of *D. conzattii* to examine, it is to his credit that the characters he emphasized are often still useful for separating these taxa. We have provided an updated character table (Table 1) that should be helpful in the differentiation of the three new species described here.

Redetermination of the available material resulted in roughly a 70% reduction in the number of documented occurrences of *D. riojae* from what might have been reported based on an uncritical review of locations based on herbarium material. At the least, this constitutes a reaffirmation of the rarity of this species. The realization that *D. conzattii* is an element of the Veracruz flora is very interesting. As far as we can tell, these are the first reports of the species for Veracruz. Material from the Cordillera de Guanacaste, and the Cordillera de Tilarán, Costa Rica, represents a distinct new species, *D. costaricensis*. The discovery of a new species, *Diospyros tuxtlensis*, from the Sierra de Los Tuxtlas does not come as a shock, since this region is renowned for having numerous endemic species of plants and animals. The distributions of the closely allied taxa, *D. tuxtlensis* and *D. costaricensis*, are notable in light of some recent interest in Los Tuxtlas-Costa Rica disjunctions (Hammel 1997). In addition to occurring in native stands of vegetation, individuals of this taxon should be sought as conserved trees in local gardens and pastures. This taxon seems to be a rare endemic of the Sierra de Los Tuxtlas, and could be in need of formal protection.

We have not seen female flowers of any of these species. The only description of a female flower that we have seen in the literature is by Carranza (2000) and refers to material from Queretaro (*D. gomeziorum*). The lack of flowering Ebenaceae material in herbaria, as pointed out by Gomez-Pompa (1964) and Wallnöfer (2001), and clearly demonstrated by our sample, makes searching for taxonomically informative vegetative characters a particularly attractive proposal (Gomez-Pompa 1964). Below we provide a key to the species described in this paper that emphasizes vegetative characters. Male flower and inflorescence characters (Table 2) can be used to supplement the following key if desired. It should be noted that *D. tuxtlensis* is not treated in Table 2, since flowering material is not currently known.

TABLE 1. Vegetative and fruiting morphology across the described taxa.

	gomeziorum	costaricensis	conzattii	riojae	tuxtlensis
Life form and size	Trees or shrubs to 20 m tall	Buttressed trees to 35 m tall	Trees or shrubs, 8–10 m tall	Trees, rarely shrubs, to 25 m tall	Trees, 8–10 m tall
Leaf shape	lanceolate to ovate to elliptic	ovate to elliptic, rarely widely-obovate	lanceolate to elliptic to ovate	elliptic, oblong, obovate, or nearly oval	elliptic
Leaf margin	beveled, sometimes ciliolate, not thickened	curved under near base, not thickened	curved under near base, intramarginal thickening	slightly recurved, thickened, sometimes ciliolate	flat, slight intramarginal thickening
Leaf luster (both sides)	shiny	dull	dull	shiny	dull
Leaf vestiture below	glabrous to sparsely subappressed hairy	sparsely appressed hairy, sometimes glandular	usually glabrous, very rarely glandular	glabrous	glabrous to sparingly appressed puberulent
Leaf bloom above	glaucous to pruinose-scintillant	very rarely glaucous-scintillant	glaucous	sometimes slightly pruinose or scintillant	slightly scintillant
Epidermal cells of lamina above	not large and not thickened	not large and not thickened	not large and not thickened	large and thickened	somewhat large and thickened
Epidermal cells of lamina below	puncticulate	puncticulate	puncticulate	puncticulate	conspicuously puncticulate
Midrib vestiture above	sparsely to densely hirtellous to deltoid scaly	glabrous to golden hirtellous	very sparsely hirtellous	glabrous, sometimes sparingly glandular	glabrous
Midrib topography above	narrowly caniculate	shallowly concave	caniculate, sometimes raised	shallowly concave	shallowly concave
Number of major lateral veins	(8–)11–13(–14)	9–12	9–14	8–12	8–9
Emergences on venation above	2°–3° granular papillose	none	none	2°–3° granular papillose	3° granular papillose
Petiole color above	yellow-green to olive-green	nearly black	pale green to green-brown	light green to chartreuse to amber	golden-brown

Table 1. continued

	gomeziorum	costaricensis	conzattii	riojae	tuxtlensis
Petiole color below	olive-green to dark brown, glistening	light olive-green to very dark brown	pale green to green-brown	light green to chartreuse to amber	dark purple
Fruiting calyx posture	spreading	spreading to moderately reflexed	spreading to slightly reflexed	arcuate-reflexed to spreading	strongly reflexed
Fruiting sepal apices	apices ascending	apices straight to quite incurved	apices straight	apices incurved to ascending	apices straight
Fruiting sepal length	19–20 mm long	(16–)22 mm long	24 -31 mm long	7–25 mm long	26–40 mm long
Fruiting sepal shape	lanceolate to narrowly elliptic or obovate	lorate to lanceolate	narrow to linear triangular	oblong, narrowly deltoid or ovate	ovate to widely lanceolate
Fruiting pedicels	(4)5–8(–11) mm long, not stout	3–18 mm long, stout	(7–)12–15 mm long, stout	7–12 mm long, stout	14 mm long, stout
Fruit hypodermis	thin	thick	intermediate	thick	thick

TABLE 2. Reproductive morphology of four similar taxa from Mexico and Costa Rica.

	Diospyros gomeziorum	Diospyros costaricensis	Diospyros conzattii	Diospyros riojae
Male inflorescence	fascicles on previous year's growth, solitary on new growth	cymes from previous year's growth, cymes from new growth	cymes from previous year's growth, cymes from new growth	fascicles from previous year's growth, fascicles from new growth
Male corolla tube shape	urceolate-campanulate	long-urceolate	long-urceolate	urceolate-campanulate
Male corolla tube interior vestiture	sparingly hirtellous, hairs sometime erratic	lower-third of tube short golden pubescent, hair direction erratic	sparsely puberulent, densest from mid-tube to tube bottom	deltoid scaly at mid-tube
Stamens	20	17–19	30	18
Anthers	2 mm long, oblong-ovate to ovate, minutely granular, short slits near apex	2.3–2.5 mm long, several minute hairs at apex, short lateral slits in distal 2/3 to 1/2	3–3.5 mm long, lanceolate, apiculate, short lateral slits near apex	± 2.5 mm long, lance-ovate, constricted near the apex
Filaments	0.3–0.8 mm long, ascending-puberulent	1–1.5 mm long, glabrous to densely erect hispidulous	3 mm long, minutely hairy	1 mm long, hirtellous, especially along margin

A KEY TO *DIOSPYROS RIOJAE*, *DIOSPYROS CONZATTII* AND SOME ALLIED BLACK ZAPOTES

1. Leaves dull, laxly revolute (loosely rolled under) near the base of the leaf; neither the 2° nor the 3° upper leaf surface venation granular papillose.
   2. Buttressed trees up to 35 m tall and 1.5 m in diameter; petiole color above nearly black; leaf margin or intramarginal zone not thickened (viewing bottom surface); midrib above shallowly, and often widely, concave, or crimped lengthwise by the adjacent sides of the lamina (boxed in); midrib glabrous to golden hirtellous; currently known only from Costa Rica _____ **4. Diospyros costaricensis**
   2. Trees or shrubs, 8–10 m tall, lacking buttresses as far as known; petiole color above pale green to green-brown; leaf margin or intramarginal zone thickened (on bottom surface); midrib above narrowly caniculate, the canal(s) raised or ± even with the lamina; midrib very sparsely hirtellous; currently known only from Veracruz, Oaxaca, and possibly from Chiapas _____ **3. Diospyros conzattii**
1. Leaves shiny or dull, margins flat or sometimes subrevolute, but never loosely rolled under near the base; 2° or 3° venation, or both, usually granular papillose on upper leaf surface.
   3. Leaf margin beveled outward from the upper leaf surface, down to the lower leaf surface; epidermal cells of the upper lamina surface not large and conspicuous with thickened anticlinal cell walls; leaves often copiously glaucous-pruinose; fruiting calyx spreading, fruiting sepals with ascending apices; fruiting pedicels generally slender _____ **2. Diospyros gomeziorum**
   3. Leaf margin never beveled; epidermal cells of the upper lam'na surface large and conspicuous, having thickened anticlinal cell walls; leaves sometimes somewhat pruinose or scintillant, but never with copious bloom; fruiting calyx spreading to strongly reflexed, apices various; fruiting pedicels very stout
      4. Leaves shiny, often tending towards oblong, oval or obovate, but may also be elliptic; leaf margins thickened, rounded from the top leaf surface to the bottom; petiole color below light green to chartreuse or amber; fruiting sepals 7–25 mm long, spreading to arcuate-reflexed, the apices incurved to ascending; fruiting pedicels 7–12 mm long _____ **1. Diospyros riojae**
      4. Leaves dull, elliptic; leaf margins flat or with a slight intramarginal thickening visible on the bottom surface; petiole dark purple below; fruiting sepals 26–40 mm long, strongly reflexed, the apices straight; fruiting pedicels 14 mm long _____ **5. Diospyros tuxtlensis**

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TAXONOMY OF NORTH AMERICAN SPECIES OF *OLDENLANDIA* (RUBIACEAE)

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ABSTRACT

This paper presents a taxonomic treatment of nine species of *Oldenlandia* occurring as native or adventive in United States or Mexico. The subgenus *Oldenlandia* is represented by four species: *O. corymbosa, O. lancifolia, O. uniflora*, and *O. boscii*. Subgenera for the remaining species are undetermined. Four species are native to Mexico: *O. pringlei, O. microtheca, O. ovata*, and *O. drymarioides*. A ninth species, *O. salzmannii*, is native to South America and adventive in northwest Florida and adjacent Alabama. Keys, descriptions, and scanning electron micrographs of the seeds are provided.

RESUMEN

Este artículo presenta un tratamiento taxonómico de nueve especies de *Oldenlandia* que ocurren como nativas o adventicias en Estados Unidos o México. El subgénero *Oldenlandia* está representado por cuatro especies: *O. corymbosa, O. lancifolia, O. uniflora* y *O., boscii*. Los subgéneros para la especie restante son indeterminados. Cuatro especies son nativas de México: *O. pringlei, O. microtheca, O. ovata* y *O. drymarioides*. Una novena especie, *O. salzmannii*, es nativa de Suramérica y adventicia en el noroeste Florida y Alabama adyacente. Se proporcionan claves, descripciones, y fotografías al microscopio electrónico de barrido de las semillas.

Oldenlandia L. (Hedyotideae; Rubiaceae) is a genus of about 100 species (Verdcourt 1976) distributed worldwide in warm, subtropic, and tropic regions. It was named by Linnaeus for Henrik Bernard Oldenlan, a Danish physician and botanist of the 17th century.

Bremekamp's monograph (1952) of the African species of *Oldenlandia* recognized 61 species in 16 subgenera. Verdcourt (1976) treated 37 species of *Oldenlandia* in the *Flora of Tropical East Africa*, and 25 species (1989) in the *Flora Zambesiaca* region. Other authors have recognized 12 species in West Tropical Africa (Hepper & Keay 1963) and 7 in Gabon (Hallé 1966). Lewis (1965) commented that Africa has more *Oldenlandia* species than exist in all other tropical regions combined and is the center of its morphological diversity.

Oldenlandia was considered as only a subgenus of *Hedyotis* by Fosberg (1943) in his study of the Polynesian *Hedyotis* species; however, the foreign flo-

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ras cited here and recent American regional floras have all treated *Oldenlandia* as a distinct genus.

Terrell (1996) discussed problems of generic limits among *Hedyotis*, *Houstonia*, and *Oldenlandia* while revising *Houstonia*, a genus of 20 North American species. Terrell and Robinson (2003) circumscribed *Hedyotis* subgenus *Hedyotis*, an Asian subgenus, and recognized the genus *Exallage* as a new subgenus of *Oldenlandia*. A synopsis of the United States species of *Oldenlandia* (Terrell 1990) treated five species.

Molecular studies found *Oldenlandia* to be paraphyletic (Bremer 1996) or polyphyletic (Andersson & Rova 1999). Its species were widely distributed in the rubiaceous lineage in what Bremer (1996) and Bremer and Manen (2000) treated as the tribe Spermacoceae, that name having priority over the Hedyotideae within which it was nested. Tested members of *Oldenlandia* are dispersed in the slightly paraphyletic part of that lineage that Terrell and Wunderlin (2002), Andersson and Rova (1999) and the present authors would continue to treat as a separate tribe Hedyotideae.

Lewis (1965) described the pollen of *Oldenlandia* and other genera in detail. In *Oldenlandia* the pollen are small or medium-sized and (2–)3(4–5) aperturate.

MATERIALS AND METHODS

The taxonomic treatment is based on loans of many herbarium specimens, as cited in the representative collections. All species except *O. pringlei* and *O. drymarioides* were seen in living condition. *Oldenlandia microtheca* and *O. ovata* were studied and collected in Mexico. *Oldenlandia salzmannii* was observed in greenhouse plants. The North American species of subg. *Oldenlandia* were collected in various parts of their ranges.

Previous work on Hedyotideae has shown that capsule and seed morphology are especially important in taxonomic studies. In the present work we examined the seeds of each species by scanning electron microscopy. The results of this study are presented below in the summary of the more significant characters of each species.

RESULTS AND DISCUSSION

Oldenlandia subgenus Oldenlandia

The type species of *Oldenlandia*, *O. corymbosa*, is a worldwide weed well established in eastern North America. Other members of subgenus *Oldenlandia* include *O. lancifolia*, adventive in Mexico, and the native U.S. species, *O. uniflora* and *O. boscii*. The latter two species differ from the other two in having axillary and terminal glomerules and slightly smaller corolla and other flower parts, but otherwise have similar characteristics (Table 1).

TABLE 1. Characters of species in subg. *Oldenlandia*.

	corymbosa	lancifolia	uniflora	boscii
Duration	annual	perennial/ann.	annual	perennial
Habit	erect/ prostr.	erect/decumb.	erect/prostr.	sprdg./prostr.
Leaves, Width mm	1–9	2–12	2–11	1–5
Stipules, L, mm	to 2	to 1.5	to 4	to 2
Inflorescence	pedicellate cymes	pedicellate cymes	glomerules	glomerules
Corollas, L, mm	1–2	1.5–2.5	0.7–1.3	0.7–1.3
Shape	rotate/tubular	rotate/tubular	rotate	rotate
Tube L, mm	0.5–1.0	0.5–1.0	0.1–0.3	0.1–0.3
Lobes, L, mm	0.5–1.0	0.5–1.5	0.7–1.2	to 0.7
Anthers, L, mm	0.2–0.3	0.4–-0.6	0.1–0.3	0.1–0.3
Filament, L, mm	0.1–0.3	0.2–0.5	0.2–0.4	ca.0.2
Stig. Lobes, L, mm	0.3–1.0	0.5–1 .2	less than 0.6	less than 0.5
Capsules, L, mm	1–2.2	1.6–3.5	1–2.5	1.5–3.0
Seeds, L, mm	0.2–0.4	0.25–0.35	0.2–0.3	0.1–0.3

The following description of subgenus *Oldenlandia* is based mainly on the North American species.

Small annual or perennial herbs usually less than 80 cm tall. Stems slender, erect, decumbent, or prostrate. Leaves 3–60 mm long, opposite, sessile or petiolate, usually linear to ovate. Stipules 1.5–4 mm long, interpetiolar, adnate to leaf bases, with 1–few marginal teeth, setae, or fimbriae. Inflorescences are of two types, either open, pedicellate, with few-flowered cymes from axillary and terminal nodes or else the flowers sessile or subsessile in axillary and terminal glomerules. Flowers tetramerous, isostylous (homostylous) in our species, but species in this subgenus elsewhere may be heterostylous. Hypanthium (calyx cup) cup-shaped or hemispheric. Corollas 0.7–2.5(–4) mm long, rotate or tubular, white or tinted pink or purple, glabrous externally; tube 0.1–1.0 mm long, shorter or longer than the 4 lobes; lobes 0.5–1.5 mm long. Anthers 0.1–0.6 mm long, dorsifixed, sessile or on short filaments inserted on corolla tube at or below corolla sinuses. Stigmas 2-lobed, 0.2–1.2 mm long, styles filiform or thickened, glabrous. Ovules on peltate placentae. Capsules 1–3.5 × 1–4 mm, bilocular, usually subglobose, fused with hypanthium, 3/4 to fully inferior, dehiscing loculicidally or also septicidally. Seeds 50–100 or more per capsule, 0.1–0.4 mm long, black, brown or tan, trigonous or conoidal-trigonous, basal face oval or elliptical, often more or less flat, lateral faces slightly or somewhat concave, hilum punctiform at apex of the apical angle, testa reticulate, areoles (cells) usually polygonal, areole walls low, rounded, indistinct, testa surface often verrucose (densely covered with minute papillae). Placenta fused with septum about 1/3–1/4 of the distance above its base. Chromosome number $x = 9$.

When compared with the other species (Table 2) the unique or unusual

TABLE 2. Comparison of four *Oldenlandia* taxa.

	subg. Oldenlandia	Pringlei	Salzmannii	Microtheca
No. of species examined	four	one	one	three
Habit	erect/prostrate	ascdg./prostr. rhizomatous	creeping	erect/decumbent
Leaves Lxw, mm	3–60 × 1–12	3–15 × 0.3–2	1.5–5.2 × 0.7–3	3–40 × 1–20
Stipules L	1.5–4 mm	0.3–1.0	to 0.5	0.5–2
Inflorescence	cymose/glomer.	cymose	solitary	cymose
Corollas L	0.6 -2.5 mm	4.0–8.5	2–5.5	2.5–7
Cor. shape	rotate/tubular	subsalv./funnel.	subsalverform	funnelform
Cor. tube L	0.1–1.0 mm	2–5	1–2.2	1–3
Cor. lobes L	0.5–1.5 mm	1.5–3.5	1–3.2	1.5–4
Anthers L	0.1–0.6 mm	0.8–1.3	0.5–0.8	0.4–1
Capsules L × W	1—3.5 × 1–4	2–3 × 2–2.5	1.5 × 1.5	1–3 × 1.5–3.5
Seeds no./caps.	50–100 +	30–50	4–14	10–34
Seeds L/dia. mm	0.1–0.4	0.2–0.4	0.3–0.5	0.4–0.7
Seeds shape	trigonous	subglob/ovoid	trigonous	angulate/irreg conoidal
Seeds, areoles	polygonal	polygonal	polygonal	none
Areole walls	low, rounded	thick, sinuous	distinct	none
Testa	reticulate	reticulate	reticulate	not reticulate
Testa surface	verrucose/other	verrucose	smooth	entangled strands
Chrom. no. *x* =	9	?	15	11, 12

features of subg. *Oldenlandia* include the following: Inflorescence either pedicellate in small cymes at the nodes or else flowers subsessile in glomerules; flowers usually isostylous (homostylous); corollas small, often 0.7–2.5 mm long, rotate or tubular; anthers 0.1–1.0 mm long; seeds 50–100 or more per capsule, 0.1–0.4 mm long, trigonous, areole walls low, rounded, indistinct; chromosome number $x = 9$ in many species worldwide.

Seed data for this subgenus are described and illustrated in Figures 1–3. Figure 1 shows typical trigonous oldenlandioid seeds in *O. corymbosa* and *O. lancifolia* with a reticulate surface composed of polygonal areoles. A basal face is often flat (Fig. 1C) and the lateral faces are flat or slightly concave. The apical hilum is shown in Fig. 1D. An enlargement of part of an areole (Fig. 1F) has a verrucose testa with low areole walls.

Two Linnaean species, the Asian *O. herbacea* and the African *O. umbellata* (Fig. 2) show trigonous seeds with concave lateral faces lacking the verrucose surface; instead with a coarsely papillose (Fig. 2C) and an apparently smooth surface (Fig. 2D).

Oldenlandia uniflora has trigonous seeds (Fig. 3) with a concave lateral face (Fig. 3B,C), a densely papillose surface and low indistinct areole walls. For

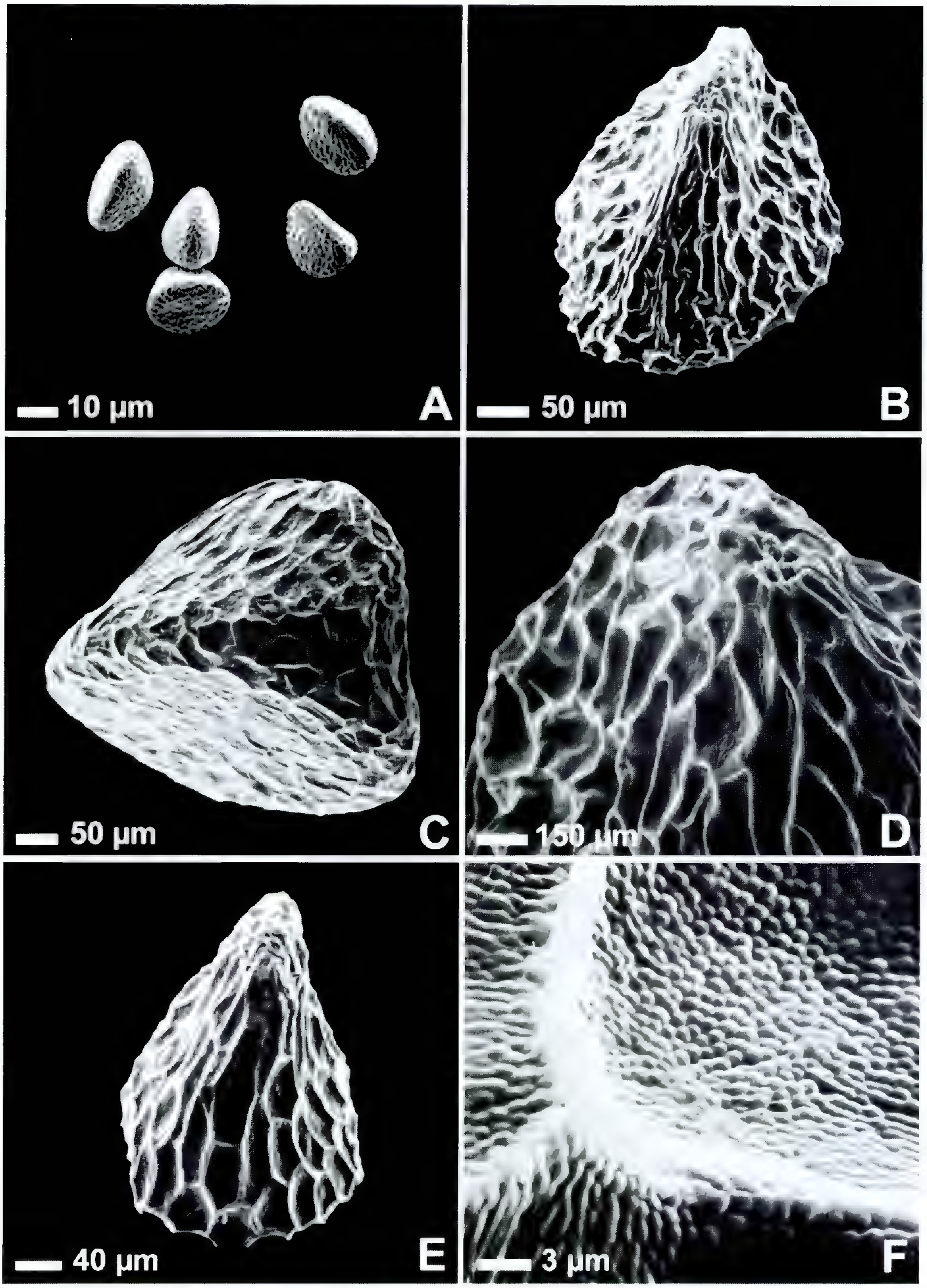


FIG. 1. Seeds of *Oldenlandia* species examined by SEM. **A–D.** *Oldenlandia corymbosa*, **A.** *Proctor 10493* (US), Jamaica; **B, D.** *Lelong 6891.2* (NCU), Florida; **C.** *Standley 52679* (US), Honduras. **E–F.** *Oldenlandia lancifolia*, *Vasquez et al. V-1324* (XAL), Mexico. **A.** Views of 5 seeds; **B, E.** End views; **C.** Tilted showing basal and lateral surfaces; **D.** Hilum at apex; **F.** Areoles enlarged.

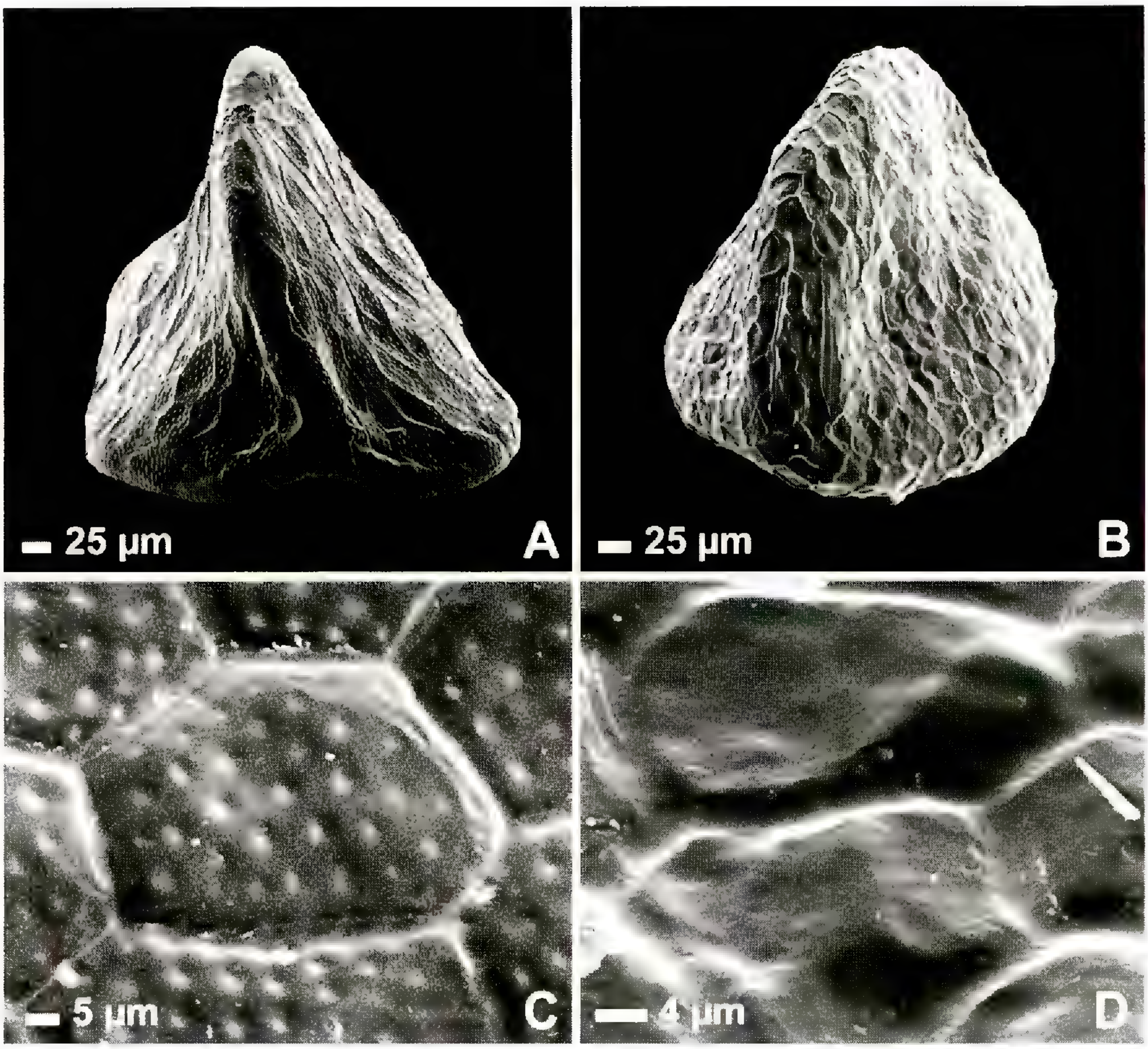


Fig. 2. Seeds of *Oldenlandia* species examined by SEM. **A, C.** *Oldenlandia herbacea*, *Fosberg 40749* (US), Nigeria. **B, D.** *Oldenlandia umbellata*, *Fosberg 51929* (US), Ceylon. **A–B.** End views; **C–D.** Areoles enlarged.

comparison with seeds of subgenus *Oldenlandia* two trigonous seeds are shown (Fig. 3D,E) from the Asian species, *O. lapeyrousii*, belonging to the subgenus *Exallage* (Terrell & Robinson 2003).

Oldenlandia species not in subgenus Oldenlandia

Table 2 summarizes the more important characters of the remaining species as well as those of subgenus *Oldenlandia*. The remaining species are not readily assignable to new subgenera until more data are known about other genera.

Oldenlandia pringlei, is restricted to San Luis Potosí, Mexico. Its more significant characters are as follows: Plants small, herbaceous, rhizomatous, ascending or prostrate; leaves linear; flowers in open, few-flowered cymes, heterostylous; corollas 4.0–8.5 mm long, subsalverform in contrast with the small, rotate or tubular corollas present in subg. *Oldenlandia*; anthers 0.8–1.3 mm long; seeds 30–50 per capsule, subglobose, ellipsoid, or ovoid instead of

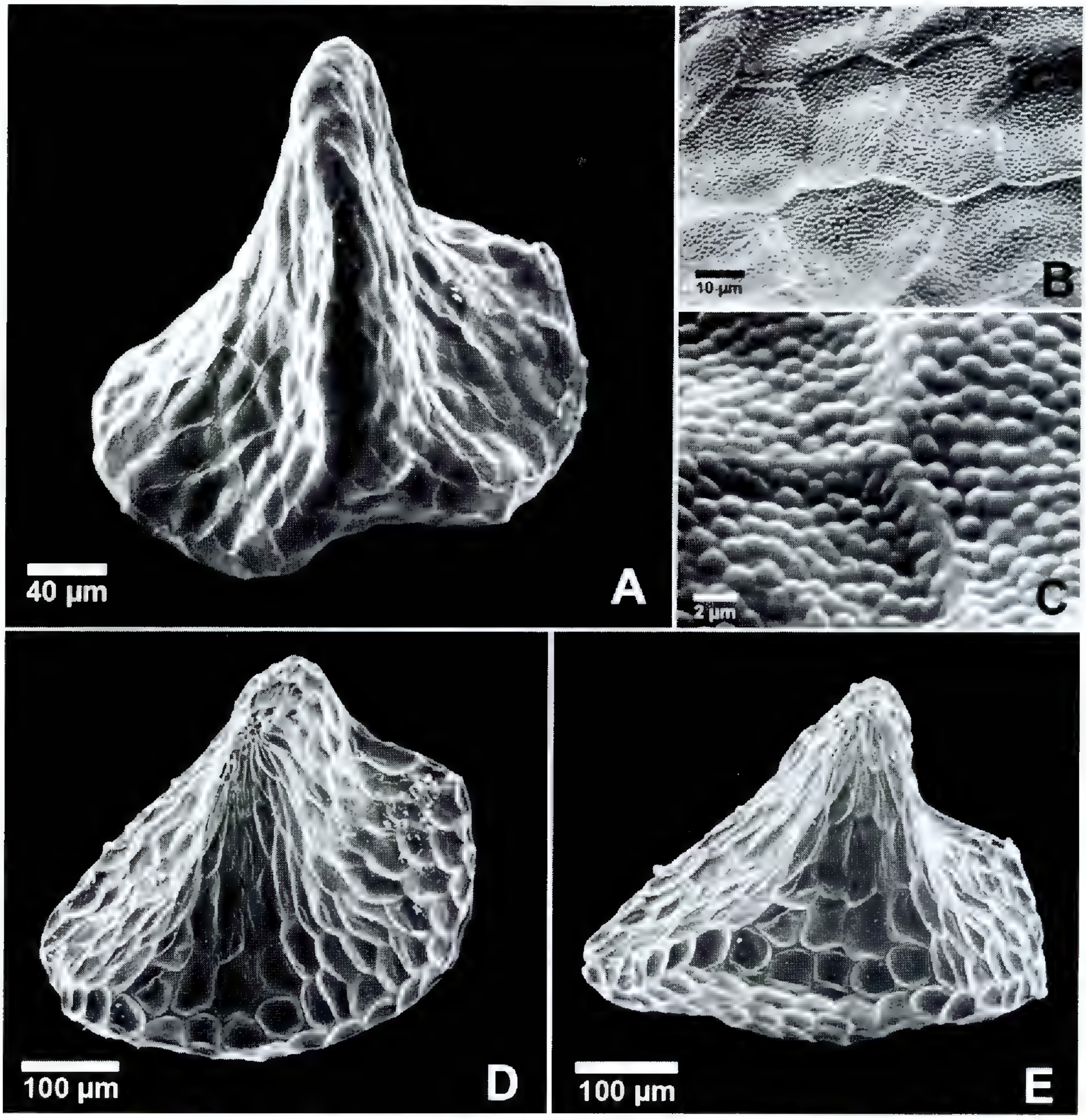


FIG. 3. Seeds of *Oldenlandia* species examined by SEM. **A–C.** *Oldenlandia uniflora*, *Leonard 7450* (FSU), South Carolina. **D–E.** *Oldenlandia lapeyrousii*, *Smith 9079* (US), Fiji. **A, D, E,** end views; **B–C.** Two views of enlarged areoles.

trigonous, and areole wall rather thick and sinuous; chromosome number not known. Ventral and dorsal views of the ellipsoid seeds with their sinuous thick-walled areoles are shown in Figure 4 A,B. The ventral view shows the centric punctate hilum.

Oldenlandia salzmannii is a South American species established in northwestern Florida and adjacent Alabama. The plants are herbaceous, creeping perennials, whereas other *Oldenlandia* species may be prostrate but rarely or not creeping; leaves small, 1.5–5.2 mm long; stipules small, to 0.5 mm long; flowers solitary, pedicellate; corollas subsalverform; capsules small, 1.5 × 1.5 mm; seeds only 4–14 per capsule, 0.3–0.5 mm long, trigonous, areole walls distinct;

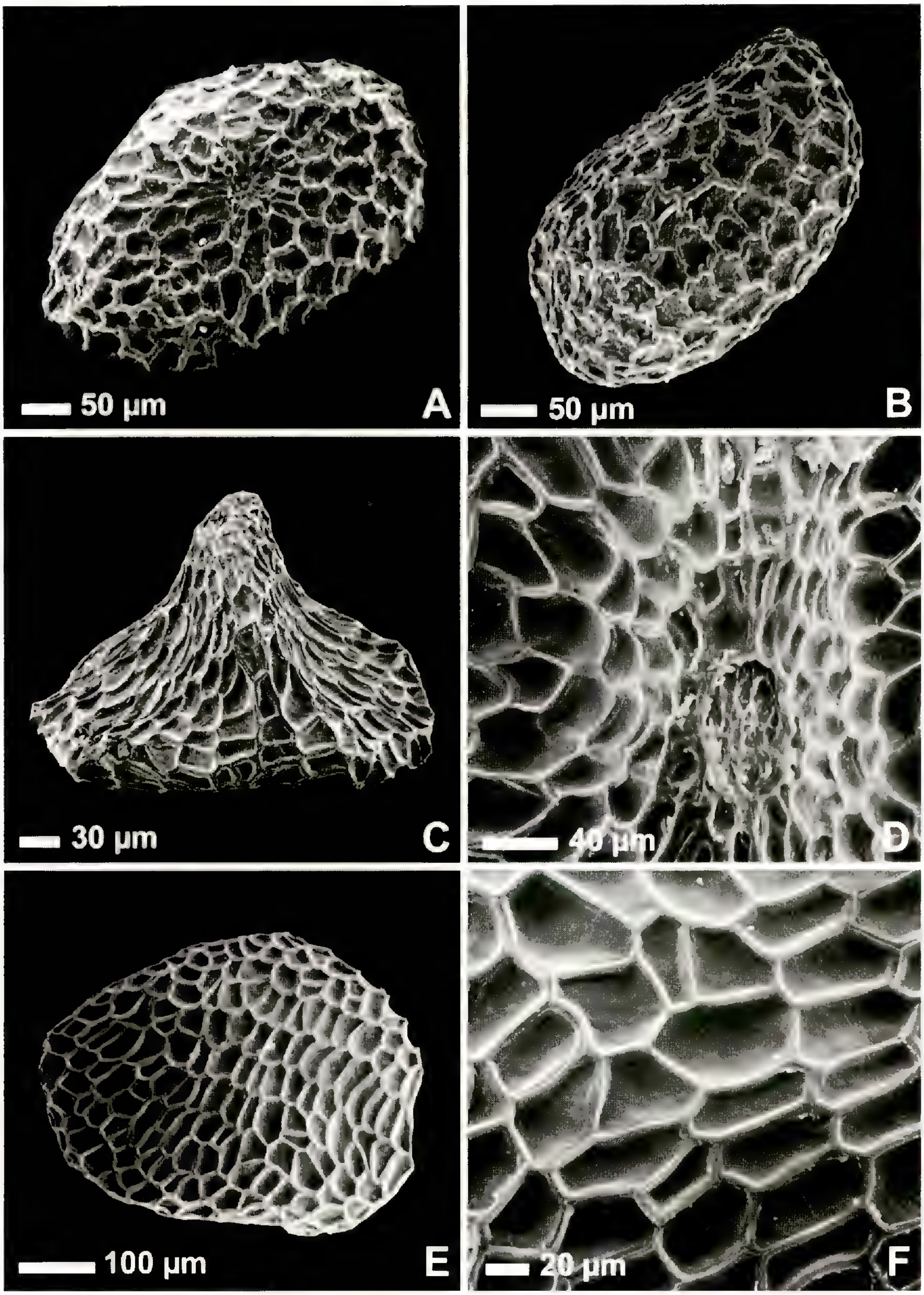


Fig. 4. Seeds of *Oldenlandia* species examined by SEM. **A–B.** *Oldenlandia pringlei*, *Pringle 3758* (US), Mexico. **C–F.** *Oldenlandia salzmannii*, *Burkhalter & Hand 6537* (UWFB), Florida. **A.** ventral view; **B.** dorsal view; **C.** side view; **D.** hilar area; **E.** basal surface; **F.** areoles.

chromosome number $n = 15$; $2n = 30$, a unique number in Hedyotideae (Lewis 1966b). Figure 4 C–E shows a trigonous seed with concave lateral faces, an apical hilum, and polygonal areoles with straight walls.

The *Oldenlandia microtheca* group includes three Mexican species, *O. microtheca, O. ovata, and O. drymarioides.* Their relationships to other species or groups are somewhat in question, but they have been named *Oldenlandia* and appear closer to that genus than to any other. *Oldenlandia drymarioides* is a rarely collected species with a close resemblance to *O. ovata*. It is tentatively considered a distinct species.

The characteristics (Table 2) of the three species may be summarized as follows: Small herbs, annual or perennial; flowers in cymes, heterostylous; corollas 2.5–7.0 mm long, funnelform; capsules 1–3 mm long; seeds 10–34 per capsule, 0.4–0.7 mm long, angulate or irregularly conoidal, surface irregularly honeycombed or alveolate, areoles lacking, coalesced, replaced by entangled vermiform strands; chromosome number $x = 11, 12$. These species are notable for their unusual seeds (Fig. 5), which differ conspicuously from those of all other *Oldenlandia* species. The seeds lack the usual reticulate testa and instead have a jumbled mass of entangled vermiform strands, a condition here referred to as coalescent areoles in reference to their running together (Fig. 5 C,F). These seeds are larger and fewer per capsule as opposed to subgenus *Oldenlandia* and show a range of shapes from irregularly and obtusely angulate to irregularly conoidal. Coalescent areoles and a chromosome number of $x = 11$ are known in *Houstonia* subgenus *Chamisme* section *Ericotis* of southwestern U. S. and Mexico (Terrell 1996), but those species are otherwise quite distinct from the *O. microtheca* group.

TAXONOMIC TREATMENT OF NORTH AMERICAN SPECIES

Oldenlandia L., Sp. Pl. 119.1753. *Gerontogea* Cham. & Schlecht., Linnaea 4:154.1829. TYPE: *O. corymbosa* L., designated by Hitchcock and Green (1929). *Hedyotis corymbosa* (L.) Lam., Tabl. Encycl. 1:272. 1792. Lectotype: Plumier, Nov. Pl. Amer. t.36. 1703, cited by Jarvis et al. (1993) and Verdcourt (1976). Four other generic synonyms were listed by Standley (1918).

KEY TO UNITED STATES SPECIES OF *OLDENLANDIA*, NATIVE OR ADVENTIVE

1. Creeping, mat-forming perennials; leaves 1.5–5.2 mm long; adventive in northwest Florida and adjacent Alabama _____ **6. O. salzmannii**

1 Erect, spreading, decumbent, or prostrate annuals or perennials; leaves (3–)5–60 mm long; native or widely established species.

2. Flowers and capsules on pedicels more than 3 mm long, not in glomerules _____ **1. O. corymbosa**

2. Flowers and capsules in axillary or terminal glomerules, sessile or pedicels less tnan 3 mm long.

3. Annual; leaves 2–11 mm wide, ovate to elliptic _____ **3. O. uniflora**

3. Perennial with woody tap root; leaves1–3(–5) mm wide, linear to narrowly elliptic _____ **4. O. boscii**

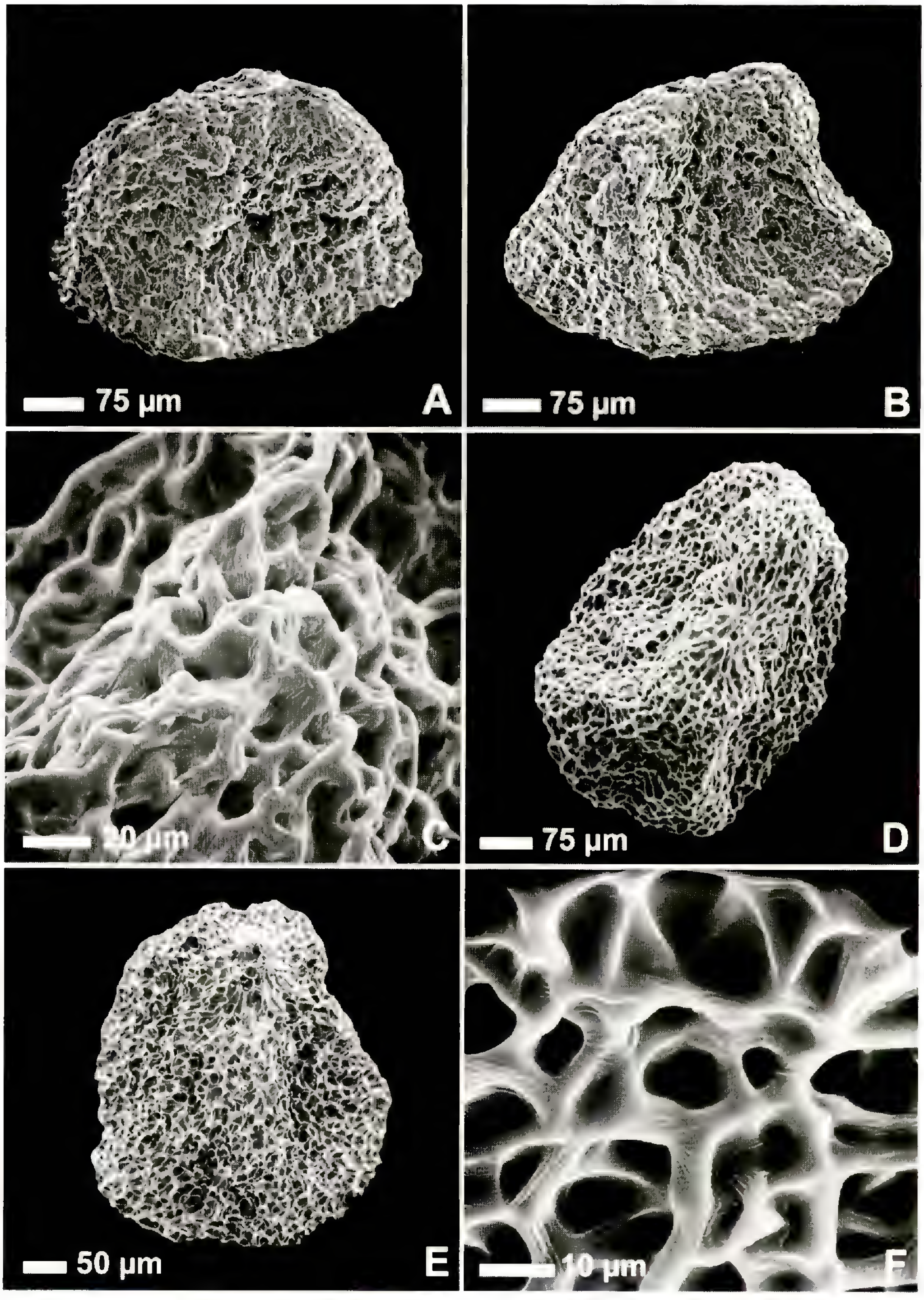


Fig. 5. Seeds of *Oldenlandia* species examined by SEM. **A–C.** *Oldenlandia microtheca*, **A–B.** *Schiede 390* (K), Mexico; **C.** *Pennell 17920* (US), Mexico. **D–F.** *Oldenlandia ovata*, *Crutchfield & Johnston 5600B* (TEX), Mexico. **A–B.** side views; **D–E.** ventral views including hilar areas; **C–F.** enlargement of coalesced areoles.

KEY TO MEXICAN SPECIES OF *OLDENLANDIA*, NATIVE OR ADVENTIVE

1. Corollas 0.7–2.5 mm long, rotate or tubular; anthers 0.2–0.6 mm long; seeds 0.1–0.4 mm long, trigonous.
   2. Plants often 10–24 cm tall; inflorescence with 1–6 pedicels per node, pedicels usually 2–13 mm long; anthers 0.2–0.3 mm long; capsules 1–2.2 × 1.3–2.8 mm, locules not saccate, apices truncate or retuse _____ **1. O. corymbosa**
   2. Plants often 15–60 cm tall; inflorescence with 1(–3) pedicels per node, pedicels 5–15(–30) mm long ; anthers 0.4–0.6 mm long; capsules 2–3.5 × 2.5–3.5(–4) mm, locules appearing inflated or saccate, apices rounded or beaked _____ **2. O. lancifolia**
1. Corollas 2.5–8.5 mm long, subsalverform or funnelform; anthers 0.4–1.3 mm long; seeds 0.2–0.7 mm long, subglobose, ovoid, or irregularly angulate.
   3. Plants often with rhizomes; leaves 0.3–2 mm wide; seeds subglobose, ellipsoid, or ovoid, testa reticulate, areoles polygonal; endemic to San Luis Potosí, Mexico _____ **5. O. pringlei**
   3. Plants without rhizomes; leaves 1–20 mm wide; seeds angulate or irregularly conoidal, testa not reticulate, areoles lacking, coalescent, replaced by entangled strands.
      4. Perennials; plants 9–42 cm tall; leaves 2–20 mm wide; flowers heterostylous _____ **7. O. microtheca**
      4. Annuals; plants less than 20 cm tall; leaves 1–9.5 mm wide; flowers isostylous.
         5. Basal leaves absent or smaller than cauline _____ **8. O. ovata**
         5. Basal leaves larger than cauline _____ **9. O. drymarioides**

1. Oldenlandia corymbosa L. Sp.Pl.119.1753. *Hedyotis corymbosa* (L.) Lam., Tab. Encycl. 1:272.1792. TYPE: Plumier, Nov. Pl. Amer. Gen. 42, t.36.1703. (Verdcourt 1976; Jarvis et al. 1993).

Small annual herb. Stems 10–24(–40) cm tall, slender, tetragonal, erect, spreading, decumbent, or prostrate, glabrous or puberulent toward base or at nodes, with 1-many branches. Leaves (5–)10–40 × 1–7(–9) mm, sessile or short-petiolate, 1-nerved, narrowly elliptic, elliptic, narrowly oblong, or linear, glabrous, margins glabrous or ciliolate near leaf bases, apices acute or apiculate. Stipules to 2 mm long, to 3 mm wide, whitish, truncate or rounded, with 0–few marginal teeth or setae to 3 mm long. Inflorescence cymose, flowers isostylous, peduncles absent or present, similar to pedicels, usually 5–15 mm long, filiform, pedicels from most nodes, 1–6 per node, usually 2–13 mm long, filiform. Hypanthium glabrous or scabrous; calyx lobes 0.5–1.3 mm long, slightly exceeding capsule, lanceolate, sometimes ciliolate on margins and sinuses, acute. Corollas 1–2 mm long, rotate or tubular, white or occasionally faint lavender or pink, partly obscured by calyx lobes; tubes 0.5–1 mm long, throat with ring of white, sometimes clavate, hairs; lobes 0.5–1 mm long, ovate, spreading. Anthers 0.2–0.3 mm long, ovate, whitish or purplish, on filaments 0.1–0.3 mm long, attached to sinuses of corolla tube. Stigma lobes 0.3–1.0 mm long, style thickened. Capsules 1–2.2 × 1.3–2.8 mm, subglobose or slightly wider than long, not or slightly compressed, glabrous, 4/5 to fully inferior, thin-walled, fragile, apices truncate or retuse. Seeds 50–100 or more per capsule, 0.2–0.4 mm long, usually brown, trigonous, hilum apical, punctiform, testa reticulate, areoles polygonal,

their walls low, rounded, indistinct, walls and testa surface densely covered with minute papillae. Flowering all year in tropical climates. Chromosome number: $n = 9, 18, 27$; $2n = 18, 36, 54$ (Lewis 1964, 1965, 1966c).

Distribution and habitats.—Pantropic weed. United States: adventive and becoming more common in Atlantic and Gulf Coastal Plains and Mississippi Embayment. North Carolina, South Carolina, Georgia, throughout Florida, southern parts of Alabama, Mississippi, and Louisiana, to eastern Texas. Mexico: Nayarit, Tabasco, Chiapas (probably more frequent in Mexico than indicated by available records). Standley (1918) did not give any records for Mexico and United States, listing only West Indies, Central America, and South America in the Western Hemisphere. Hawaii: Oahu, Hawaii, Maui. Eastern Hemisphere. Disturbed places, lawns, roadsides.

Discussion.—The description refers to the diploid race of var. *corymbosa*. Further comments on varieties in Lewis 1965, 1966c, Verdcourt 1976; Sivarajan and Biju 1990. Specimens cited below are considered to be var. *corymbosa*.

Representative collections. **U.S.A. FLORIDA. Alachua:**, lawn, McCarty Hall, University of Florida, Gainesville, *D'Arcy 2160* (FLAS). **Collier:** 1 mi S of Naples, *Cooley et al. 9071* (USF). **Dade:** Homestead, *Radford & Leonard 45744* (USF). **Escambia**: West Brainerd St, near Pensacola, *Burkhalter 2965* (FLAS). **Glades:** 3 mi SW of Palmdale, *Ward 5185* (FLAS). **Hillsborough:** NW of International Airport, Tampa, *Lakela 24642* (FLAS, USF). **Manatee:** Bradenton, *Cuthbert 1442* (FLAS). **Orange:** Orlando, *Schallert 1590* (FLAS). **Palm Beach:** 836 Biscayne Drive, West Palm Beach, *Cassen 559* (FLAS). **Pinellas:** Gulfport, *Thorne 13874* (US). **Sarasota:** opposite entrance to Pine Park west of US 441, *Ward & Burch 3110* (FLAS). **LOUISIANA. Orleans:** Tulane University campus, *Sundell 2028* (NO). **SOUTH CAROLINA. Florence:** Wynn Owens farm, Evergreen, *Swails 83/971* (USCH). **Richland:** 6511 Helena Road, Columbia, *Nelson 402* (FLAS).

2. Oldenlandia lancifolia (Schumach.) DC., Prodr. 4:425.1830. *Hedyotis lancifolia* Schumach. [in Schumach. & Thonn.], Beskr. Guin. Pl. 72.1827. TYPE: GHANA: Valley of Aquapim, *Thonning 210* (LECTOTYPE: C; ISOLECTOTYPE: S, n.v.).

Hedyotis commutata Schult. & Schult. f., Mant.3:134.1827. TYPE: PUERTO RICO: *Bertero s.n.*, n.v.

Perennial herb (rarely annual). Stems 15–60 cm tall, slender, sometimes flattened after drying, erect, decumbent or sprawling on other vegetation, often rooting at base, glabrous to densely puberulent. Leaves 10–60 × 2–12 mm, sessile or subsessile, 1-nerved, linear, lanceolate, or elliptic, glabrous, margin revolute, apices acute. Stipules to 1.5 mm long, to 2.5 mm wide, whitish, truncate or rounded, with 1–few marginal teeth or setae to 3–4 mm long. Inflorescence cymose, flowers isostylous, pedicels from most nodes, 1–2(–5) per node, 5–15(–30) mm long. Hypanthium glabrous or pubescent; calyx lobes 0.7–1.6 mm long, exceeding capsules, lanceolate or deltate, scaberulous to puberulent, acute. Corollas 1.0–2.5 mm long, rotate or tubular, white; tube 0.5–1 mm long; lobes 0.5–1.5 mm long, usually slightly longer than tube, ovate, spreading. Anthers 0.4–0.6 mm long, oblong, on filaments 0.2–0.5 mm long exserted ca. 0.5 mm beyond throat, attached at sinuses of corolla. Stigmas lobes 0.5–1.2 mm long, linear,

exserted ca 1 mm beyond throat, styles 0.5–1 mm long, filiform. Capsules 1.6–3.5 × 2.5–4 mm, subglobose or slightly wider than long, slightly compressed, glabrous, 3/4 to 9/10 inferior, thin-walled, fragile, apices rounded or somewhat beaked especially after dehiscence, locules appearing saccate. Seeds numerous per capsule, 0.25–0.35 mm long, trigonous, hilum apical, punctiform, testa reticulate, areoles polygonal, their walls low, rounded, indistinct, walls and testa surface densely covered with minute papillae. Chromosome number: $n = 18$, $2n = 36$ (Lewis 1965).

Distribution and habitat.—Tropical Africa; introduced or adventive in South America, Central America, West Indies, and Mexico. Recorded from Mexico in Tamaulipas, Veracruz, Oaxaca, Chiapas, and Tabasco. Low altitudes in moist places along streams, swamps, forest openings.

Discussion.—Verdcourt (1976) provided data on African varieties of *O. lancifolia*.

Many American collections of this species have been misidentified as *O. herbacea* (L.) Roxb., an Asian species; see key below. The occurrence of any *O. herbacea* collections in Mexico has not been substantiated by us.

KEY TO *OLDENLANDIA LANCIFOLIA* AND *O. HERBACEA*

1. Stems weak, often reclining on other vegetation, sometimes flattened in drying; leaves 2–12 mm wide; corollas 1.0–2.5 mm long; capsules 2.5–4 mm wide, subglobose or wider than long, locules of capsules often appearing inflated or saccate _____ **O. lancifolia**

1. Stems erect, solid, tetragonal; leaves 1 -4 mm wide; corollas 2.5–4.7 mm long; capsules 1.5–2.5 mm wide, subglobose or longer than wide, locules not appearing inflated or saccate _____ **O. herbacea**

Both *Hedyotis commutata* and *H. lancifolia* were created in 1827, and apparently have equal priority. The epithet lancifolia has been the choice of Verdcourt (1976), Howard (1989), and others in floras.

Representative specimens. **COSTA RICA. Cartago:** Rio Reventazon, Catie Agric. Station, Turrialba, *Hill et al. 17735* (HILL). **San Jose:** Vic. of El General, *Skutch 3932* (GH, MO, US). **Limon:** Vic. of Guapiles, *Standley 37296* (US). **GUATEMALA. Izabal:** Vic. of Quirigua, *Standley 24267* (GH, US). **HONDURAS. Comayagua:** Vic. of Siguatepeque, *Standley 56039* (US). **MARTINIQUE.** 1 1/2 km S of Ajoupa-Bouillon, *Kimber 687* (WIS). **MEXICO. Chiapas:** Mpio. of Salto de Agua, W of Catazaja on road to Villahermosa, *Breedlove & Davidse 55281* (CAS, MICH, TEX). **Tamaulipas:** 8 mi from Tampico on Mante highway, *Johnston & Graham 4077* (MEXU, MICH, TEX). **Veracruz:** Rio Solosuchil a orillas del Campamento Hnos. Cedillo, Hidalgotitlan, *Brigada Vasquez 172* (XAL). **NICUARAGUA. Zelaya:** Puerto Isabel, *Narvaez S. 2890* (GH). **PANAMA.** Bocas del Toro, Changuinola to 5 mi S at jct. of Rios Changuinola and Terebe, *Lewis et al. 796* (GH).

3. Oldenlandia uniflora L. Sp. Pl.1:119.1753. *Hedyotis uniflora* (L.) Lam.,Tab.Encycl. 1:272.1792. *Edrastima uniflora* (L.) Raf., Actes Soc. Linn. Bordeaux 6:269.1834. TYPE: VIRGINIA: *Clayton 587* (LINN -155.3!; ISOTYPE: BM!).

Hedyotis auricularia Walter, Fl. Carol.85.1788. (non *H. auricularia* L., Sp. Pl. 101.1753). TYPE: n.v.
Oldenlandia glomerata Michx., Fl. Bor.-Amer. 1:83. 1803. *Hedyotis glomerata* (Michx.) Elliott,

Sketch Bot. S. Carolina 1:188. 1816. *Stelmotis glomerata* (Michx.) Raf., New Fl. 4:101. 1836. *Stelmanis glomerata* (Michx.) Raf., Autik. Bot. 13. 1840. TYPE: "in humidis Carolinae inferioris," n.v.

Hedyotis virginica Spreng., Pl. Min. Cogn. Pug. 2:34. 1815. TYPE: n.v.

Hedyotis fasciculata Bertol., Mem.Reale Accad. Sci. Ist. Bologna 2:306. 1850.*O. fasciculata* (Bertol.) Small, Fl. S.E. U.S. 1106. 1903. *H. uniflora* var.*fasciculata* (Bertol.) W.H. Lewis, Amer. J. Bot. 49:865. 1962. TYPE: n.v.

Oldenlandia littoralis C. Mohr, Bull. Torrey Bot. Club 24:27. 1897. TYPE: ALABAMA: Mobile, low wet places, borders of ponds, Grand Bay [near Mobile], Sep 6, 1888, *C. Mohr s.n.* (LECTOTYPE, here designated: UNA!).

Small annual herb. Stems 2–70 cm tall, slender, erect, spreading, decumbent, or prostrate, densely white-hirsute or villous to glabrous, much branched. Leaves 3–20(–28) × 2–11 mm, sessile or short-petiolate (to 2 mm), ovate or elliptic, hirsutulous or pubescent to glabrous above or pubescent only on midribs and nerves, glabrous or pubescent on nerves beneath, margins ciliolate to glabrous, apices acute or obtuse. Stipules to 4 mm long, to 3 mm wide, whitish, divided near base into 1–few (sometimes branched) ciliate, linear or lanceolate, curved or straight teeth or setae to ca 5 mm long. Inflorescence with 1–many isostylous flowers in axillary and terminal glomerules, sessile or on pedicels to ca 3 mm long, sometimes flowering when plants are very small. Hypanthium hirsute to glabrous; calyx lobes 0.8–2.5(–4) × 0.5–2 mm, strongly one-nerved near base, ovate or ovate-lanceolate, pubescent and ciliate to glabrous. Corollas 0.8–1.3 mm long, rotate, white or pale blue; tube 0.1–0.3 mm long; lobes 0.7–1.2 × 0.5–1.1 mm, usually shorter than the calyx lobes, ovate. Anthers 0.1–0.3 mm long, ovate, purple, on filaments 0.2–0.4 mm long attached to corolla tube at sinuses. Style and stigma 0.2–0.6 mm long, stigma lobes included in tube, style thickened. Capsules 1–2.5 × 1–3 mm, subglobose or slightly wider than long, densely hirsute with whitish hairs or pubescent to glabrous, 7/8 or fully inferior, walls medium thick, apices truncate, dehiscence loculicidal. Seeds numerous per capsule, 0.2–0.3 mm long, black, brown, or tan, trigonous, hilum apical, punctiform, testa reticulate, areoles polygonal, their walls low, rounded, indistinct, walls and testa surface densely covered with papillae. Flowering in United States in spring (Florida), summer, fall. Chromosome number: $n = 18, 36$; $2n = 36$ (Lewis 1962).

Distribution and habitats.—United States: Mainly in Atlantic and Gulf Coastal Plains and Mississippi Embayment. New York (Long Island) south to southern Florida, west to eastern Oklahoma, eastern Texas, southern Arkansas, southeastern Missouri, western Kentucky, and western Tennessee. West Indies in Cuba, Puerto Rico, and Jamaica. Not recorded from Mexico. Wet or moist places, lake shores, swamps, stream banks and sand bars, pine and deciduous woods (often in openings), savannahs, fields, roadsides, gravel pits.

Discussion.—Variation in leaf shape and plant vesture does not appear to be taxonomically significant. This species produces flowers at an early age: one collection from Virginia was flowering when plants were 4 cm tall.

Representative collections. **CUBA. Isle of Pines:** San Pedro and vicinity, *Britton & Wilson 14703* (CM). **U.S.A. FLORIDA. Glades:** 8.6 mi SE of Palmdale, *Lewis 5682* (TEX). **Highlands:** 6.7 mi S of US 27 and Florida 70 intersection, *Ray et al. 10420* (USF). **Manatee:** 2 1/2 mi N of Duette and road 62, *Shuey 2113* (DS). **Sarasota:** 6 mi SE of Sarasota, *Ward & Burch 3196* (MO). **Walton:** 4 mi S of Freeport, *Davis & Davis 15845* (CM). **GEORGIA. McIntosh:** NE part of Sapelo Island, *Duncan & Adams 17858* (MICH). **LOUISIANA. Beauregard:** 1 1/2 mi S of Bayou Amacoco, *Ewan 20089* (NO). **East Baton Rouge:** Magnolia, *Brown 2329* (LSU). **St. Tammany:** near jct of hwys. I-10 and I 59, *Darwin & Sundell 918* (NO). **MARYLAND. Prince Georges:** Magruder Landing, *Smith 5131* (MT). **MISSISSIPPI. Hancock:** 0.5 mi W of St. Louis Bay and hwy. 90, *Lewis 5688* (TEX). **NEW YORK. Long Island:** near Long Pond, Wading River, *Miller s.n.*, 8/23/1878 (CM). **NORTH CAROLINA. Hoke:** 4 mi SSW of Ashley Hts., *Ahles 36373* (ASU, CM, MICH). **OKLAHOMA. Atoka:** 0.5 mi NW of Boehler, *Taylor 20365* (KANU). **SOUTH CAROLINA. Aiken:** Montmorenci, *Ahles & Crutchfield 55058* (ARIZ, ASU, BALT, CLEM, CM, DS, KANU, KY, LL, MICH, TEX, US, VPI). **TEXAS. Cherokee:** Larissa, *Palmer 8613* (CAS). **Nacogdoches:** 3.5 mi S of Nacogdoches, *Lewis & Oliver 5510* (DS, TEX). **VIRGINIA. Accomac:** Parksley, *Norton s.n.* 9/11/02 (MARY).

4. Oldenlandia boscii (DC.) Chapm., Fl. South.U.S.181.1860. *Hedyotis boscii* DC., Prodr. 4:420. 1830. TYPE: U.S.A: Carolina, 1798–1800, *Bosc s.n.* (G-DC (n.v.); microfiche US!).

Small perennial herb with woody taproot to ca 6 mm thick. Stems often numerous, 5–30 cm tall, slender, spreading, decumbent or prostrate, forming mats or mounds to ca 4 dm wide, glabrous to minutely papillose or puberulent, much branched. Leaves 10–25(–30) × 1–3(–5) mm, sessile, linear to narrowly elliptic, glabrous to minutely papillose or puberulent above, glabrous or scabrous on midrib beneath, margins glabrous or scabrous, sometimes revolute, apices obtuse or acute. Stipules to 2 mm long and wide, whitish, truncate or deltate, with 1–several marginal teeth or setae to 2 mm long. Inflorescence with 1–several (–many) isostylous flowers in axillary and terminal glomerules, sessile or subsessile. Hypanthium glabrous or minutely papillose; calyx lobes 0.8–2 × 0.3–0.8 mm, strongly 1-nerved, deltate to lanceolate. Corollas 0.8–1.3 mm long, rotate, white, pink, or lavender; tube 0.1–0.3 mm long; lobes 0.7–1.2 mm long, ca. 1–2 mm wide, shorter than the calyx lobes, ovate. Anthers 0.1–0.3 mm long, broadly elliptic, on filaments ca. 0.2 mm long attached to corolla at sinuses. Stigma lobes included in tube, style and stigma less than 0.5 mm long, style thickened. Capsules 1.5–3 × 1.5–2.5 mm, subglobose or often slightly longer than wide, verrucose or papillose varying to glabrate, truncate or retuse, 7/8 to fully inferior, walls medium thick, dehiscence loculicidal. Seeds numerous per capsule (to at least 120), 0.1–0.3 mm long, black or brown, trigonous, hilum apical, punctiform, testa reticulate, areoles polygonal, their walls low, rounded, indistinct, walls and testa surface densely papillose. Flowering April to November. Chromosome number: $2n = 36$, based on three collections (Lewis 1962).

Distribution and habitats.—United States: Mainly in the Atlantic and Gulf Coastal Plains, Mississippi Embayment, and Ozarks in the southeastern states: Southeastern Virginia, North Carolina, South Carolina, Georgia, northern Florida, and west to central and western Tennessee, southeastern Missouri, east-

ern Oklahoma, and eastern Texas. Wet or moist places, stream banks, lake shores, roadsides, ditches, fields, woods, savannahs, disturbed open places.

Representative collections. **U.S.A. ALABAMA. Escambia:** Conecuh River bottoms 6 mi E of Boykin on US 29, *Kral 44857* (KANU). **ARKANSAS. Faulkner:** Conway, *Haas 678* (US). **FLORIDA. Gadsden:** Floodplain Appalachicola River at Chattahoochee, *Godfrey 67526* (FLAS, TEX, USF). **Leon:** 10 mi S of Tallahassee on Spring Hill Road, *Godfrey 62904* (MT, TEX, USF). **Suwannee:** Live Oak, *Curtiss 6649* (ISC, US). **GEORGIA. Miller:** 7 mi ESE of Colquitt, *Thorne 5199* (MT, US). **LOUISIANA. Allen:** 7.2 mi W of Kinder, *Shinners 21522* (MICH). **Grant:** Louisiana road 8 ca 4 1/2 mi NE of Colfax, *Allen et al. 7802* (NO). **Sabine:** Zwalle, Toledo Bend Reservoir, Sabine River, *Demaree 48352* (NO). **Washington:** Along Pearl River E of Angie, *Brown 17866* (LSU). **MISSISSIPPI. Jackson:** Biloxi, *Tracy 6422* (US). **Oktibbeha:** 10 mi S of Starkville, *McDaniel 2661* (NO). **NORTH CAROLINA. Scotland:** Sink Hole Bay, SE side of SR 1622, *Berg 1156* (NCU). **OKLAHOMA. McCurtain:** 1 mi N of Bethel, *Waterfall 14776* (DUKE). **SOUTH CAROLINA. Aiken:** Montmorenci, *Ahles & Crutchfield 55054* (ASU, CM, FLAS, KANU, KY, MICH, TEX, USCH, VPI). **TEXAS. Bastrop:** Bastrop, *Tharp s.n.*, 8/7/38 (CAS, DS, MICH, US). **Jefferson:** Beaumont, *Palmer 12720* (US). **Nueces:** Padre Island, *Jones 2244* (WWF). **VIRGINIA. Southampton:** Predler's Pond, Nottoway Swamp, SW of Sedley, *Fernald & Long 7625* (US). **Sussex:** Airfield Millpond, SW of Wakefield, *Fernald & Long 14419* (US).

5. Oldenlandia pringlei B.L. Rob., Proc. Amer. Acad. Arts 27:169. 1892. *Hedyotis pringlei* (B.L. Rob.) WH Lewis, Rhodora 63:222. 1961. TYPE: MEXICO. SAN LUIS POTOSI: alkaline plains, Hacienda de Angostura, 27 Jun 1891, *C.G. Pringle 3758* (LECTOTYPE, here designated: GH!; ISOLECTOTYPES: BM!, F!, K!, MICH!, MO!, MSC!, PH!, US-3!, VT!).

Small perennial herb from slender scaly rhizomes and slender tap root. Stems 5–20 cm tall, slender, subterete, scaly toward base, ascending or prostrate, densely puberulent to glabrate, branched from base or upper nodes. Leaves 3–15 × 0.3–2 mm, thickened, slightly fleshy, sessile, linear, glabrous or granular-puberulent. Stipules usually 0.3–1.0 mm long, somewhat sheathing, deltate or ovate, with marginal gland-tipped teeth or lobes.Inflorescence in terminal or axillary few-flowered cymes, pedicels to ca. 10 mm long, flowers heterostylous. Hypanthium glabrous; calyx lobes to 2 mm long, 0.2–1.0 mm wide, lanceolate or ovate-lanceolate, obtuse. Corollas 4.0–8.5 mm long, subsalverform or narrowly funnelform, white, with dark nerves; tube 2–5 mm long, 0.7–2 mm wide at throat, slightly widened distally, glabrous within proximally, puberulent distally; lobes 1.5–3.5 × 0.7–1.3 mm, lanceolate-ovate, puberulent within. Anthers 0.8–1.4 mm long, narrowly oblong. Stigma lobes 1–1.3 mm long, subglobose. Pin flowers with stigmas exserted to 2.5 mm beyond throat; anthers included, filaments 0.5–1.0, attached near midpoint of tube to just below throat. Thrum flowers with anthers sessile or on short (0.5 mm) filaments, exserted at throat, stigmas located in distal part of tube or becoming slightly exserted. Capsules 2–3 × 2–2.5 mm, usually slightly longer than wide, subglobose or broadly oblong, slightly to somewhat compressed, thin- or rather thick-walled, fully inferior, apex rounded, retuse or truncate, tardily dehiscing loculicidally by a narrow opening. Seeds ca 30–50 per capsule, (0.2–)0.3–0.4 mm diam., subglobose, ellipsoid, or ovoid, hilum punctiform, centric, testa reticulate, areoles polygonal,

their walls thick, sinuous, testa surface verrucose. Flowering May to September. Chromosome number not known.

Distribution and habitats.—Mexico: endemic in Rio Verde area, southern part of San Luis Potosí. Fourteen collections have been seen. Rio Verde is sometimes spelled Rioverde. Saline or alkaline flats or plains, sometimes in gypseous soil, associated with *Prosopis* and *Acacia*.

Discussion.—B.L. Robinson cited *Pringle 3758* in the protologue, but did not designate the GH specimen as holotype. Robinson worked at the GH and we are designating the GH specimen as lectotype, from among at least nine isolectotypes.

Representative specimens. **MEXICO. San Luis Potosí:** 5.6 mi E of jct. to El Centro in Rio Verde on hwy 70/86, mpio.Rio Verde, 21°54' N, 99° 53' W, *Nesom 6635* (TEX); 0.7 mi N of Las Tablas (RR crossing), mpio.Ciudad del Maiz, *Nesom 6674* (TEX); Media Luna, near Rio Verde, *Palmer 68* (CM, F, GH, MO, NY, US); Minas de San Rafael, Guascama, *Purpus 5014* (BM, F, GH, MO, NY, US); San Bartolo, mpio. Rio Verde, *Rzedowski 5821* (ENCB, MICH); 5 km S of Rio Verde, sobre el camino a El Zapote, *Rzedowski 8022* (ENCB); 9 km E of Rio Verde, carretera a Rayon, *Rzedowski et al. 24788* (ARIZ, ENCB, LL, MICH, MSC, TEX, US); Las Tablas, *Takaki 44* (ENCB); 2 km W of Estacion Angustura, 30 km N of Rio Verde, *Takaki 2014* (ENCB); 9 km SE of Villa Juarez, mpio.Villa Juarez, *Takaki 2021* (ENCB).

6. Oldenlandia salzmannii (DC.) Benth. & Hook. f. ex B.D. Jacks., Index Kew. 1:142. 1893; 2:336. 1893. *Anotis salzmannii* DC., Prodr. 4:433. 1830. *Hedyotis salzmannii* (DC.) Steud., Nom. Bot. ed. 2.1:728.1840. TYPE: "circa Bahiam requens," *Salzmann s.n.*, n.v.

Hedyotis thesiifolia A. St. Hil., Voy. Distr. Diam. 1:397. 1833. *Oldenlandia thesiifolia* (A. St. Hil.) K. Schum. in Mart., Fl. Bras. 6, 6:270. Pl.127, f.1.1889.TYPE: n.v.

Additional synonyms cited by Lewis (1966a:44).

Small perennial herb, rooting at nodes and forming mats. Stems creeping, very slender, tetragonal-rounded, glabrous, often much branched. Leaves 1.5–5.2 × 0.7–3 mm, rather thick, sessile or subsessile, broadly elliptic, elliptic, or ovate, glabrous to sparsely hirsute with pointed white hairs to 0.8 mm long, margins glabrous to ciliate especially at or near apex, base rounded, apex rounded. Stipules to ca 0.5 mm long, truncate, with 0–few marginal fimbriae to ca 0.7 mm long and 0–few minute dark sessile glands. Inflorescence with flowers heterostylous, 4–5-merous, solitary on slender pedicels 2–12 mm long. Hypanthium densely to sparsely hirsute with widely spreading, white, pointed hairs ca 0.5–1 mm long; calyx lobes numbering 4–5(–6), 1–2.2 × 0.7–1.0 mm, lanceolate, ovate, or oblong, glabrous or glabrate, apices obtuse or rounded. Corollas 2.5–5 mm long, subsalverform, pink, lavender, light purple, or white, usually with white center; tubes 1–2.2 mm long, ca 2 mm wide at base, broader than long, 2–3 mm wide at throat, tube and throat within densely hirsutulous or pubescent with spreading white hairs about 0.5 mm long; lobes numbering 4(–5), 1–3.2 × 0.9–2 mm, as long as or longer than corolla tubes, ovate, spreading 90 degrees and apices recurved, striate-puberulent within with minute white hairs. Anthers numbering 4(–5), 0.5–0.8 × 0.2–0.4 mm, dark blue, oblong

or elliptic. Stigma lobes 0.5–1.5 mm long, elliptic or linear, whitish, diverging at maturity. Pin flowers with anthers on filaments 0.3–0.7 mm long, attached in distal 1/3 of corolla tube; stigma lobes exserted 1–2 mm beyond throat, styles ca 2–3 mm long; slender, greenish or whitish. Thrum flowers with anthers exserted beyond throat on filaments 0.8–1.1 mm long; stigma lobes included in tube, style ca 1 mm long. Capsules ca 1.5 mm long and wide, subglobose, hirsute with stiff white hairs, 7/8 to fully inferior, walls medium thick, dehiscence loculicidal. Seeds 4–14 per capsule, 0.3–0.5 mm long, black, trigonous, hilum apical, punctiform, testa reticulate, areoles polygonal or rectangular, areole walls distinct, sometimes double, testa surface apparently featureless. Flowering June to August in western Florida and adjacent Alabama.

Chromosome number.—$n = 15$, $2n = 30$. Lewis (1966b) as *Hedyotis salzmannii*, based on *Lewis 6448* (MO), also in FTG, US! Pond edge in botanical garden, Rio de Janeiro, Guanabara State, Brazil. Lewis stated that meiosis was irregular and about 2/3 of pollen grains were shriveled. Terrell examined the US specimen and concluded that the plant does not closely resemble the plants from Florida. Thus, this chromosome number must be considered as tentative.

Distribution and habitats.—South America: Brazil, Argentina, Chile, Uruguay, Paraguay. United States: Locally adventive in Florida near Pensacola in Escambia and Santa Rosa counties and in adjacent Baldwin Co., Alabama, in roadside ditch, by ponds, and at edge of a marsh. First discovered by J. R. Burkhalter in Escambia Co. (Fosberg & Terrell 1985). Burkhalter sent Florida plants to Terrell, who grew them in a greenhouse for several years.

Discussion.—The name, *O. salzmannii*, is here accepted as correct pending study of the type specimens. In Index Kewensis, vol. 1, B.D. Jackson, editor, listed "*Anotis Salzmanni* DC., l.c. =*Oldenlandia Salzmanni*." In volume 2, p. 336, Jackson listed "*Oldenlandia Salzmanni* Benth. & Hook. f. Gen. ii. 58.—Bras." It was pointed out by Fosberg and Terrell (1985) that Bentham and Hooker did not validly publish the combination *Oldenlandia salzmannii* because they merely listed it under *Oldenlandia*, and did not state anything further about their intentions or viewpoints. Jackson validated the name *Oldenlandia salzmannii* by publishing it in volume 1 of Index Kewensis. We may alternatively cite only B.D. Jackson.

The description of the later name *Hedyotis thesiifolia* A. St. Hilaire (1833) states that the leaves are linear, which casts some doubt on its identity, as the subject plants have ovate leaves. Later, Schumann (1889; see above) published a very good description of *H. thesiifolia* along with an excellent drawing, citing several synonyms, including *Hedyotis salzmanni*. Unfortunately, we have to stick with the earliest name, *O. salzmannii*, the one chosen by Fosberg & Terrell (1985). The taxonomy and nomenclature of this species need further study involving the variation in the native South American plants.

Collections from **U.S.A. ALABAMA. Baldwin:** Near Orange Beach, just N of W end of Cotton Bayou, E of Ala. 161, *Burkhalter 8753* (UWFP). **FLORIDA. Escambia:** near Pensacola, S of US 98, 0.2 mi W of Fairfield Drive, *Burkhalter 5408* (FLAS); Gonzalez, N of Chemstrand Road (FL C-297), E of Judy St., R30W, T1N, Sec. 14, *Burkhalter & Hand 6537* (FLAS, FSU, UWFP); SW of Pensacola, E side of Herrion Bayou, N of US 98, *Burkhalter 8838* (FLAS, UWFP).

7. Oldenlandia microtheca (Schltdl. & Cham.) DC., Prodr. 4:428. 1830. *Gerontogea microtheca* Schltdl. & Cham., Linnaea 5:169. 1830. *Hedyotis microtheca* (Schltdl. & Cham.) Steud., Nomencl. Bot. ed. 2.1:728.1840. TYPE: MEXICO. VERACRUZ: "Barranca de Tioselos in umbrosis," Papantla, Sep 1828, *Schiede & Deppe 390* (HOLOTYPE: HAL!); see further notes on isotypes in text below.

Gerontogea deppeana Schltdl. & Cham., Linnaea 5:169. 1830. *Oldenlandia deppeana* (Schltdl. & Cham.) DC., Prodr. 4:428. 1830. *Hedyotis deppeana* (Schltdl. & Cham.) Steud., Nomencl. Bot. ed. 2. 1:727. 1840.TYPE: MEXICO. VERACRUZ: San Andres, Aug 1828, *Schiede & Deppe 391* (HOLOTYPE: HAL!; ISOTYPES: HAL! MO-Bernhardi!).

Perennial herbs with roots sometimes thick and woody. Stem base often woody, to 5 mm thick. Stems 9–42 cm tall, slender, erect or decumbent, glabrous, puberulent, or densely scabrid, branches to 30 cm long. Leaves subsessile or with partly winged petioles to 5 mm long, blades (6–)10–30(–40) × 2–13(–20) mm, 1-nerved, quite variable in size and shape, ovate, lanceolate, or elliptic, varying to linear in Chiapas populations, glabrous to scaberulous or puberulent above, or densely scabrid in Chiapas populations, glabrous beneath, bases cuneate, rounded, or tapering, apices obtuse, acute, or subacuminate. Stipules to ca 2 mm long, to 3 mm wide, scarious, whitish, deltate to lanceolate, glabrous or puberulent, with marginal gland-tipped teeth to ca 1 mm long, apices truncate to acuminate or lobed. Inflorescence terminal, in few-flowered cymes, flowers heterostylous, pedicels to 15 mm long, slender or filiform, glabrous or scaberulous. Hypanthium glabrous or with minute hairs on margins of sinuses; calyx lobes 0.5–1.3 × 0.3–0.5 mm, usually 1/4 as long to subequal to corolla tube, deltate to lanceolate, apices obtuse or acute. Corollas 2.5–7 mm long, funnelform, white or lined with purple, glabrous externally; tube 1–3 mm long, somewhat widened distally, 0.5–1.3 mm wide at base, 1–2 mm wide at throat, puberulent within with dark gland-tipped hairs 0.1–0.2 mm long; lobes 1.5–3(–4) × 0.8–1.8 mm, ovate or lanceolate, glabrous or puberulent within. Anthers 0.4–1 mm long, 0.2–0.3 mm wide, elliptic or oblong. Stigma lobes to 1.4 mm long , linear, often somewhat coiled at maturity. Pin flowers with corolla lobes 1–2(–3) times longer than corolla tube, anthers located just below corolla throat, sessile, stigma lobes exserted 1–2 mm beyond corolla throat, styles ca 2–3.2 mm long. Thrum flowers with corolla lobes 2/3–1 times as long as corolla tube, anthers exserted beyond throat on filaments ca 0.3–1 mm long, stigma lobes located near midpoint of corolla tube. Capsules 1–3 × 1.5–3.5 mm, usually wider than long or subequal, subglobose to obovate, slightly to rather strongly compressed, glabrous or glabrate, 3/4–9/10 inferior, thin- or rather thick-walled,

apices retuse, truncate, or broadly rounded, dehiscing loculicidally and then septicidally. Seeds 10–32 per capsule, 0.4–0.7 mm long, black or dark brown, irregularly and obtusely angulate or conoidal-angulate, hilum appearing either apical or centric, punctiform, testa not reticulate, areoles lacking, strongly coalesced, replaced by entangled vermiform strands. Flowering throughout the year. Chromosome number: $n = 11$ (Lewis in Terrell et al. 1986).

Distribution and habitats.—Mexico: Chiapas, Hidalgo, Oaxaca, Puebla, San Luis Potosí, Veracruz. Standley (1918) included Yucatan in the range, but I have not seen any specimens from there. Gravelly, rocky or sandy soil, slopes, banks, crevices of cliffs, in open or in pine or deciduous forests, and evergreen cloud forest in Chiapas, alt. 1000–2700 m.

Discussion.—This species is closely related to *O. ovata* and *O. drymarioides* as shown by its morphology. Chiapas collections by Breedlove and Raven are linear-leaved and scabrid and occur in cloud forests. They were judged to be a possible new variety, but they appear to be otherwise similar to *O. microtheca* and, lacking more collections, are tentatively included in *O. microtheca* s.l.

The type specimens for *O. microtheca* have been seen in the Halle (HAL) and other herbaria, but have presented problems in interpretation of label data. In addition to the holotype cited above at HAL, other collections included possible isotypes, as follows: (1) a specimen at K labelled as 390, but lacking a locality; (2) a specimen at HAL labelled 390 and "Barranca de Tioselos," but dated August 1829, not September 1828; (3) a type at B presumably destroyed, shown in photos of "Types of Berlin Herbarium" deposited at F, MO, NY, US; this labelled as "*O. micrantha* n. sp." and as *Hedyotis micrantha* Schlecht., a name unpublished in these combinations, (4) a specimen at HAL and MO, supposedly not a type, labelled from "In sylvis Papantlae," thus agreeing with the citation under *O. microtheca* in Linnaea 6:414. 1831. The protologues of *Gerontogea microtheca* and *G. deppeana* appeared under the numbers 390 and 391 on the same page. Any question of priority seems to have been settled by Standley (1918), who adopted *O. microtheca* in his monographic treatment of *Oldenlandia* for the North American Flora.

Standley (1918) listed *O. latifolia* Martens & Galeottii as a synonym of *O. microtheca*, but these are two separate species that are superficially so much alike, even in floral details, that it is difficult to identify them without the seeds. Like *O. ovata* and *O. drymarioides*, the seeds of *O. microtheca* are irregularly angulate or irregularly conoidal and have coalescent areoles as described here. In *Hedyotis latifolia* (Martens & Galeotii) Walpers, however, the seeds are flat and reticulate. The latter has a chromosome number of $n = 17$, compared to $n = 11$ in *O. microtheca*. A detailed study of the morphology of all parts of these two species in separate genera indicated that the best distinguishing characters are those in the following key.

KEY TO *OLDENLANDIA MICROTHECA* AND *HEDYOTIS LATIFOLIA*

1. Seeds 0.4–0.7 mm long, irregularly angulate or conoidal-angulate, testa not reticulate, areoles appearing coalesced, replaced by entangled vermiform strands; hilum not or scarcely visible; corolla tube 1–3 mm long, 1–2 mm wide at throat; corolla lobes in pin flowers 1–2(–3) times longer than tube, lobes in thrum flowers 2/3–1 times as long as tube; anthers in pin flowers attached just below corolla throat _____ **Oldenlandia microtheca**

1. Seeds 0.5–1 mm long, flat, testa finely reticulate, with polygonal areoles; hilum punctiform, near center of ventral face of seeds; corolla tube 1.5–5 mm long, 1.8–3 mm wide at throat; corolla lobes in both flower types 1/2–1 times as long as tube; anthers in pin flowers attached near midpoint of corolla tube _____ **Hedyotis latifolia**

Representative collections. **MEXICO. Chiapas:** Sumidero de Tuxtla, 22 km N of Tuxtla Gutierrez, 4500 ft., *Raven & Breedlove 20123* (DS, NY); same loc., *Breedlove 10650* (DS, NY); Summit of Chuchil Ton, NE of Bochil, mpio. of San Andres Larrainzar, 2700 m, *Breedlove 29269* (DS, MICH, MO); 7 km NE of Bochil along road to Simojovel, mpio. of Bochil, *Breedlove & Smith 32308* (DS); 11–15 km NW of Soyalo on road to La Bombana and Chicoasen, mpio. of Osumacinta, 1000 m, *Breedlove 33756* (DS, MICH, MO); 6–8 km WNW of Soyalo, mpio. of Soyalo, *Breedlove 37168* (DS, ENCB, MICH, MO). **Hidalgo:** Vic. of Molango, road to Lolotla, Distr. Molango, *Moore 2399* (GH, MICH). **Oaxaca:** Mpio. San Pedro Ixcatlan, Cerro Quemado, al W del Poblado de Cerro Quemado, *Calzada 10351* (XAL). **Puebla:** 15 km adelante de Xicotepec de Juarez rumbo a Poza Rica, *Chazaro B. 569* (XAL); Near Metlaltoyuca, *Goldman 26* (GH, US); near Ocostoc below Teziutlan, *Sharp 45826* (GH, MEXU, TENN, US); Mpio. Cuetzalan, San Miguel Tzinacapan, *Turra 1524* (ENCB); El Reparo, Mpio. de Hueytamalco, *F. Ventura A. 414* (CAS, CHAPA, ENCB, US); Carretera Cuetzalan San Andresito, mpio. Cuetzalan, *Zola B. 253* (XAL). **San Luis Potosí:** Las Canoas, *Pennell 17920* (F, GH, MEXU, MICH, NY, PH, US); Tamasopo Canyon, *Pringle 3510* (F, GH, VT). **Veracruz:** Rancho La Martinica, a 5 km al N de Banderilla, mpio. Banderilla, *Calzada 4327* (XAL); 1 km al E de San Pablo, mpio. de Papantla, *Gutierrez R. 26* (ENCB); El Esquilon, mpio. Jilotepec, *Ortega O. 75* (XAL); Monte Rey, Ejido Coetzalan, Mpio. Axocuapan, *Robles H. 171* (ENCB, XAL); Below Txolo Falls near Jalapa, *Sharp 45802* (GH, MEXU, TENN, US); 6 km SW of Chiconquico, mpio. Acatlan, road to Misantla, *Terrell & Koch 5379* (CAS); Encinos, mpio. de Totutla, *F. Ventura A. 7627* (CAS, ENCB); Coacoazintla, mpio. Coacoazintla, *F. Ventura A. 8292* (CAS, CHAPA, ENCB); Filipinas, mpio. de Tlapacoyan, *F. Ventura A. 12316* (CAS, CHAPA, ENCB).

8. Oldenlandia ovata S. Watson, Proc. Amer. Acad. Arts 18:97. 1883. *Hedyotis watsonii* W.H. Lewis, Rhodora 63:222. 1961 (non *H. ovata* Thunb. ex Maxim., Bull. Acad. Imp. Sci. Saint-Petersbourg 29: 161. 1883). TYPE: MEXICO. NUEVO LEÓN: Guajuco, Mar 1880, *E. Palmer 399* (LECTOTYPE, here designated: GH!; ISOLECTOTYPES: F!, K!, NA!, US!, VT!); LECTOTYPE mislabeled later as *O. microtheca*. PARATYPES: *Ervendberg 200* (GH! atypical or not *O. ovata*); *Parry and Palmer 676 1/2* (GH!); these in GH are on the same sheet as the lectotype.

Small annual herb. Stems to ca. 20 cm tall, slender, weak, ascending, decumbent, or diffusely spreading, glabrous or puberulent. Leaves with petioles to ca 5 mm long, blades 3–14 × 1–9.5 mm, thin, 1-nerved, ovate, broadly ovate, or upper leaves elliptic, glabrous to sparsely pubescent above, glabrous beneath, bases rounded, subcordate, or subtruncate or upper leaves tapering to base, apices obtuse or acute. Stipules ca. 0.5 mm long, truncate, with gland-tipped teeth. Inflorescence terminal and axillary in groups of 1–3 flowers, cymose, pedicels filiform, 2–16 mm long, flowers isostylous. Hypanthium glabrous; calyx lobes 0.4–1.2 mm long, deltate to lanceolate, obtuse or acutish. Corollas 2–4 mm long,

short-funnelform, white, glabrous or puberulent within; tubes 1–2.2 mm long, scarcely wider distally; lobes 1–1.5 mm long, ovate. Anthers 0.4–0.7 mm long, sessile, elliptic or narrowly elliptic, attached at corolla sinuses, slightly exserted. Stigma lobes 1–1.2 mm long, linear, slightly exserted at throat, not exceeding corolla lobes, style 1.3–1.7 mm long. Capsules 1.3–2.2 × 2–3 mm, subglobose or broadly oblong, slightly wider than long, usually widest at apex, glabrous, thin-walled, fragile, 3/4–4/5 inferior, subtruncate at apex, dehiscing loculicidally and then septicidally. Seeds ca. 17–34 per capsule, 0.4–0.7 mm long, black or brown, irregularly and obtusely angulate or conoidal-angulate, hilum scarcely visible, apical, punctiform, surface often warty and bumpy, testa not reticulate, areoles lacking, strongly coalesced, replaced by entangled vermiform strands. Flowering March to December. Chromosome number: $2n = 12$ (Lewis 1962 as *Hedyotis watsonii*).

Distribution and habitats.—MEXICO: Central and southern Nuevo León and Tamaulipas south to eastern San Luis Potosí, northern Hidalgo, and Veracruz (one collection). Moist shaded rocks and outcrops along streams, rock crevices, and on canyon walls, alt. 100–1500 m, 300–5000 feet.

Discussion.—Additional nomenclatural data are provided as follows. The lectotype is labelled "March 1880," but isolectotype F is labelled "March 1–8, 1880" and states that Guajuco is 27 miles southeast of Monterrey; K and US are labelled "February to October 1880." A paratype listed above is *L. C. Ervendberg 200* (GH), Wartenberg, near Tantoyuca, prov. Huasteca, 1858, en route from San Luis Potosí to Tampico, December 1878 to February 1879. *Ervendberg 200* is either atypical *O. ovata* or not *O. ovata*; it is difficult to know which because of the condition of the specimen.

Representative collections. **MEXICO. Hidalgo:** Near Chapulhuacan, *Sharp 441822* (GH, MEXU, TENN, US). **Nuevo León:** Canyon Denuncio, Rancho La Bolla, Mpio. de Villa Santiago, *Mueller 2020* (F, GH, MICH); Sierra Madre Orientale 21 mi W of Linares, *Ripley & Barneby 13559* (NY); 0.5 mi SE of Canoas, 5.5 mi SE of Allende, *E & B. Terrell 4426* (CAS); Trail below base of Horsetail Falls, SE of Monterrey, *E. & B. Terrell 4430* (CAS); Hacienda Vista Hermosa, 35 mi S of Monterrey, *White 1555* (MICH); **Queretaro:** 4 km SW of Ahuacatlan, mpio. de Pinal de Amoles, *Rzedowski 27744* (ENCB); **San Luis Potosi:** Tamazunchale, *Fisher 45180* (BRIT, US). **Tamaulipas:** 22 mi SW of Victoria, *Crutchfield & Johnston 5600B* (TEX); 3 mi N of Villagran on Victoria Linares hwy., *Johnston & Graham 4672B* (TEX); Mpio. Hidalgo, 4.3 mi W of Adelaida-Guayabas jct., *Nesom et al. 6351* (TEX); Cerro del Picacho, mpio. de Villa de Casas, *Puig 4098* (ENCB); Along Rio Sabinas, opposite km 619 on Pan American hwy. N of El Limon, *Sharp & Hernandez X. 50393* (TENN).

9. Oldenlandia drymarioides (Standl.) Terrell, Phytologia 59:80.1985. *Houstonia drymarioides* Standl., J. Wash. Acad. Sci. 18:162.1928. *Hedyotis drymarioides* (Standl.) W.H. Lewis, Rhodora 63:221.1961. TYPE: MEXICO. TAMAULIPAS: mountains S of Victoria, alt. 1000 m, 9 Apr 1926, *Robert Runyon 870* (HOLOTYPE, designated by Standley, US!; ISOTYPE: F!). PARATYPE: same loc. and date, *Robert Runyon & B. C. Tharp 4039* (TEX!, US!).

Annual herb (protologue states perennial, but plants appear annual). Stems to ca 15 cm tall, slender, erect or decumbent, glabrous, simple or sparsely branched,

with the 3–4 internodes much longer than the leaves. Basal leaves to 12 mm long, to 5 mm wide, much larger than cauline leaves, forming a rosette, ovate or oval, rounded at base, with short petioles, glabrous or minutely puberulent; cauline leaves to 6 mm long, to 3 mm wide, few and much reduced, elliptic to narrowly elliptic. Stipules 0.5 mm long, with short marginal teeth. Inflorescence in few-flowered, terminal cymes, flowers apparently isostylous, pedicels to ca 18 mm long, filiform. Hypanthium glabrous; calyx lobes 0.5–1.2 mm long, equaling or slightly exceeding mature capsules, deltate. Corollas 2–4 mm long; short-funnelform, apparently white; tubes 1.3–2.3 mm long, scarcely wider distally; lobes ca 1–1.8 mm long, ovate. Anthers ca 0.8 mm long, sessile, oblong, attached at sinuses of corolla lobes, slightly exserted. Stigma lobes not seen Capsules 1.3–2 × 1.7–2.8 mm, slightly wider than long, slightly compressed, glabrous, thin-walled, fragile, 1/2–3/4 inferior, broadly rounded at apex, dehiscing loculicidally and then septicidally. Seeds 0.3–0.45 mm long, black, obtusely and irregularly angulate or conoidal-angulate, hilum scarcely visible, apical, punctiform, testa not reticulate, areoles lacking, strongly coalesced, replaced by entangled vermiform strands. Chromosome number not known.

Discussion.—This description is shortened due to the few collections. Further collections are needed to determine whether this species is distinct from *O. ovata*.

Recent collection. **MEXICO: Tamaulipas:** Mpio. San Carlos, Sierra de San Carlos, ca. 5 mi S of San Carlos, N side of Bufa El Diente, igneous bedrock, N-facing steep slope; scattered oaks and shrubby vegetation of *Rhus, Croton, Chiococca, Helietta, Vauquilinia*, 770 to 1100 m, 24°31.5' N, 98° 57.6' W. Flowers white, very common on moist shady bank, 17 Jun 1987, *Nesom 6049, with Norris, Martinez, Woodruff* (MEXU, TEX).

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Book Review

Ricardo Ayerza Jr. and Wayne Coates. 2005. **Chia: Rediscovering a Forgotten Crop of the Aztecs.** (ISBN 0-8165-2488-2, pbk.). University of Arizona Press, Tuscon, AZ 85719, U.S.A. (**Orders:** http://www.uapress.arizona.edu/). $14.95, 215 pp., b&w drawings, tables, index, 6" × 9".

The plant known as chia (*Salvia hispanica* and *Salvia columbariae*) has been part of the human diet, medicine chest, and culture for 4000 years. Although its' importance to humans has waned over time, there is currently a renewed interest in chia both as a food and a good source of omega-3 fatty acids. Authors Ayerza Jr and Coates have created an interesting primer on the history and uses of chia, as well as the nutritive values of the species.

The opening chapters introduce the reader to the neolithic and early meso-American diets and compare these to a modern western diet. Although these early diets were high in animal products like ours today, theirs relied heavily on lean game animals from the wild; ours consists mostly of grain fed domesticated animals. This comparison of diets and the introduction of omega-3 and omega-6 fatty acid ratio prepare the reader for a detailed discussion of fats in the human diet.

The authors have written the text on fats and oils in the human diet in a very readable way. The information is well referenced with research and related literature. Each type of lipids, cholesterol and fatty acids is discussed. Information is presented on coronary heart disease as well as the detrimental increase of omega-6 fatty acids and decrease of more healthful omega-3 fatty acids in the western diet.

After this in-depth discussion of how the omega-3/6 fatty acids fit into our diet, the authors delve into chia even further. The text includes a chapter on the history and uses of chia through information collected from codices, written histories and related cultural uses of today. Chia was important in the Aztec empire as a food, beverage, medicine, soup, and religious ceremonies. The Spanish conquest caused a decline in the use of chia because the invaders banned chia to help deter non-Christian religious ceremonies. After so many centuries, Chia is still grown in Mexico and South America, but is not as important a crop as it once was.

The remaining chapters of the book discuss other species referred to as chia, ways to determine the different species, botanical description, ecology, and cultivation information on the chia plant. Related to the earlier discussion of human diet, the authors include an interesting discussion on chia as a good source of omega-3 fatty acids. They also compare it to other omega-3 sources and discuss the potential use of chia in enriching other foods sources such as eggs with omega-3 fatty acids. One very interesting section included an introduction to the Nahua system of botanical classification.

Chia: Rediscovering a Forgotten Crop of the Aztecs is a book filled with intriguing information about chia, its' history, uses, and nutritive value. The authors have provided an excellent informative source on chia's potential as a functional food with high nutrient value, substantial amounts of vitamins and minerals, low sodium content, a substantial source of omega-3 fatty acids, and are a non-allergenic food with antioxidants and fiber. This book can be recommended to anyone interested in learning more about omega-3 fatty acids, and chia's nutritive value or history.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

NEW TAXA AND COMBINATIONS IN CULTIVATED BAMBOOS (POACEAE: BAMBUSOIDEAE)

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ABSTRACT

A new species in *Fargesia* Franch. from China, and a new variety in *Drepanostachyum falcatum* (Nees) Keng f. from the eastern Himalayas, are described. Four new combinations are made in *Borinda* Stapleton for species from western China, previously placed in the genus *Fargesia*, and one new combination is made in *Indocalamus* Nakai for a Japanese species described in *Pseudosasa* Nakai.

RESUMEN

Se describe una nueva especie de *Fargesia* Franch. de China, y una nueva variedad de *Drepanostachyum falcatum* (Nees) Keng f. del Este del Himalaya. Se hacen cuatro combinaciones nuevas en *Borinda* Stapleton para especies del Oeste de China, previamente colocadas en el género *Fargesia*, y se hace una combinación nueva en *Indocalamus* Nakai para una especie japonesa descrita en el género *Pseudosasa* Nakai.

Fargesia apicirubens Stapleton, sp. nov. TYPE: UK: Ness Botanic Garden, *C.M.A. Stapleton 1060*, 11 May 1996 (HOLOTYPE: K!).

Fargesia robusta foliis crassis lanceolatis vel fusiformis longi-apiculatis similis, sed setae oralis nullis vaginorum culmorum glabris differt.

Culms 2–4 m, 0.3–1 cm in diam., pendulous; internodes 5–18 cm, smooth, lightly white-powdery initially, becoming glossy dark green with purple spots, often apically purple-red, later orange-yellow, wall to 5 mm thick; nodes with weakly prominent supra-nodal ridge, sheath scar level and tall, mid-culm branches 6–8. Culm sheaths slowly deciduous, basally leathery and smooth, light brown with prominent red-brown ribs, apically asymmetrically rounded with a persistent red band below the blade, much shorter than internodes, glabrous, margins densely yellow-brown-setose; auricles absent; oral setae absent; ligule ca. 1 mm, truncate, initially ciliolate; blade lanceolate, erect or reflexed, glabrous, margins setose. Leaves 3–7 per ultimate branch; sheath thick, glabrous with outer margin densely white-ciliate at first, usually apically red with yellow veins; auricles and oral setae absent; ligule ca. 1 mm, truncate, purple, shortly tomentose, external ligule not evident, tomentose; blade lanceolate to fusiform, 7–10 × 0.6–1.5 cm, slightly thickened, glabrous, basally cuneate, apically long-acuminate, secondary veins 4–5-paired, one margin shortly spinescent, the other obscurely serrulate, transverse veins distinct, petiole yellow. Inflorescence racemose, unilateral; spikelets shortly pedicellate, usually subtended by densely pubescent reduced sheaths.

Introduced from Daba Shan, Shaanxi Province, China, and grown under the misapplied name *Fargesia dracocephala* T.P. Yi.

Etymology.—The epithet "apicirubens" refers to the distally red-colored sheaths and culm internodes.

Drepanostachyum falcatum var. **sengteeanum** Stapleton, var. nov. TYPE: U.S.A. OREGON: Gold Beach, Aug 1996, *S.G. Cooper s.n.* (HOLOTYPE: K!).

Drepanostachyo falcato (Munro) Keng f. var. *falcato* spiculis bifloris vel trifloris, culmis porcatis, foliis angustis similis, sed vaginis culmorum praeter annulum pilosum circumcirca fundum omnino glabris, lemmatibus scabris, paleis vix bifidis, rhachillis minus puberulis, pilis costae foliarum longioribus unifariis dispersis, vaginis foliorum haud cilatis differt.

Culms 2–4 m, 4–10 mm in diam.; internodes 10–21 cm, uniformly finely porcate, lightly white-waxy at first; nodes substantially raised, with ring of persistent, initially orange-brown, later colorless, 1–3 mm hairs. Culm sheaths abaxially glabrous except for a dense ring of 1–3 mm red-brown hairs around basal 1–2 mm; margins distally with ca. 1 mm white cilia; auricles absent; oral setae absent; ligule long-fimbriate, abaxially basally puberulous and apically glabrous. Leaf sheaths glabrous; external ligule pronounced, thin, with even ca. 0.1 mm cilia; auricles absent, shoulders glabrous, elevated; oral setae absent; ligule ca. 1 mm, rounded to acute, shortly laciniate, shortly ciliate, basally puberulous. Leaf blade to 12 × 1 cm, basally narrowly cuneate; abaxially glabrous except for sparse ca. 1 mm hairs on one side of the proximal midrib; adaxially glabrous. Spikelets with (1–)2–3(–4) florets. Lemma 7–10 mm, deeply furrowed, abaxially distally scabrous, distal margins shortly ciliate. Palea 8–10 mm, abaxially distally shortly scabrous, apex acute or very shortly bifid, shortly ciliate; keels distally scabrous. Rhachilla sections to 5 mm, mainly glabrous, apically bearded with ring of ca. 1 mm hairs.

Cultivated in U.S.A. and Europe under misapplied names that will be discussed in a further article. Presumably originating from the Himalayas.

Etymology.—This taxon is named in honor of Dr. Lee Seng Tee.

Selected specimens. **UK (cult.):** Kew, Temperate House, 1894, *Anonymous* (K); Kew, Sep 1895, *Anonymous* (K); Kew, Temperate House, 5 Jan 1897, *Gamble s.n.* (K); Kew, Himalayan House, 14 Sep 1901, *Anonymous* (K). **U.S.A. California:** Bonny Doon, *Stapleton 1136*, 6 Oct 1999 (K).

Borinda angustissima (T.P. Yi) Stapleton, comb. nov. BASIONYM: *Fargesia angustissima* T.P. Yi, J. Bamboo Res. 4(2):21. 1985.

Borinda contracta (T.P. Yi) Stapleton, comb. nov. BASIONYM: *Fargesia contracta* T.P. Yi, J. Bamboo Res., 7(2):60. 1988.

Borinda nujiangensis (Hsueh & C.M. Hui) Stapleton, comb. nov. BASIONYM: *Fargesia nujiangensis* Hsueh & C.M. Hui, Bull. Bot. Res., Harbin 18:261. 1998.

Borinda utilis (T.P. Yi) Stapleton, comb. nov. BASIONYM: *Fargesia utilis* T.P. Yi, J. Bamboo Res. 7(2):28. 1988.

Indocalamus hamadae (Hatus.) Stapleton, comb. nov. BASIONYM: *Pseudosasa hamadae* Hatus., J. Geobot. 15:86. 1967.

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ESTUDIOS EN LAS APOCYNACEAE NEOTROPICALES XXIV: *BAHIELLA* (APOCYNOIDEAE: ECHITEAE), UN DESAPERCIBIDO NUEVO GÉNERO ENDÉMICO DE BAHIA, BRASIL

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RESUMEN

Bahiella J.F. Morales (Apocynoideae, Echiteae), un nuevo género endémico al estado de Bahia en Brasil, es descrito, proponiéndose una nueva combinación, *B. blanchetii* (A. DC.) J.F. Morales y una nueva especie, *B. infundibuliflora* J.F. Morales. Se incluyen descripciones completas, ilustraciones y especímenes examinados. Adicionalmente, se realizó un análisis cladístico para determinar las posibles relaciones intergénericas de *Bahiella*, el cual incluyó un total de 44 especies (19 géneros) de la tribu Echiteae como grupo interno y 10 especies (7 géneros) de las tribus Apocyneae, Malouetieae y Mesechiteae como grupos externos. Los resultados sugieren que *Bahiella* pertenece a las Echiteae, pero sus relaciones intergenéricas más cercanas no pueden ser determinadas por ahora.

ABSTRACT

Bahiella J.F. Morales (Apocynoideae, Echiteae), a new genus endemic to Bahia, Brazil is described and illustrated. A new combination, *B. blanchetii* (A. DC.) J.F. Morales and a new species, *B. infundibuliflora* J.F. Morales are proposed. All the taxa are fully described and illustrated. Aditionally, a cladistic analysis was performed to determinate the possible intergeneric relationships of *Bahiella*, including 44 species (19 genera) as ingroup of the tribe Echiteae, and 10 species (7 genera) of the tribes Apocyneae, Malouetieae y Mesechiteae as outgroup. The results suggests that *Bahiella* belong to the Echiteae, but their intergeneric relationships can´t be established by now.

Desde su descripción por parte de Brown (1810), la familia Asclepidaceae fue tradicionalmente considerada como diferente de las Apocynaceae, pero estudios moleculares en la última década (e.g., Judd et al. 1994; Potgieter & Albert 2001; Sennblad & Bremen 1996) sugirieron que ambas debían tratarse como una sola unidad. En forma reciente, Endress & Bruyns (2000), propusieron un nuevo sistema de clasificación tratando en forma conjunta los géneros anteriormente divididos en Apocynaceae y Asclepiadaceae, reconociendo un total de cinco subfamilias. De estas, la subfamilia Apocynoideae está dividida en cinco tribus, Apocyneae, Echiteae, Malouetieae, Mesechiteae y Wrightieae, separadas principalmente por las características de la cabeza estigmática. Sin embargo, la conformación definitiva de estas tribus aún se encuentra en disputa, dado que análisis moleculares recientes (e.g., Simões et al. 2004) sugieren que al menos una de ellas no es monofilética (Apocyneae) y más estudios son necesarios con

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el objeto de definir apropiadamente sus límites. Ahora bien, la mayoría de géneros neotropicales de las tribus *Echiteae* y *Mesechiteae* fueron monografiados por Robert Woodson (1933, 1935, 1936), siendo ambos grupos relativamente fáciles de distinguir por la ausencia o presencia de coléteres en la superficie adaxial del nervio central, así como por las características de la cabeza estigmática. En los miembros de *Mesechiteae*, las láminas foliares tienen coléteres en la superficie adaxial del nervio central, ya sea agrupados en la base o distribuidos en forma irregular a lo largo de su entera longitud, aunque también pueden estar presentes en las venas secundarias (i.e., *Mandevilla*) y las cabezas estigmáticas tienen cinco costillas o proyecciones longitudinales, las cuales pueden estar restringidas a la base o distribuidas a lo largo de la cabeza. En contraposición, los miembros de la *Echiteae*, tienen láminas foliares sin coléteres en la superficie adaxial de los nervios, así como cabezas estigmáticas sin costillas longitudinales y con forma de carrete de hilo o más o menos fusiformes y con un anillo membranoso basal.

Dado que las monografías publicadas por Woodson se encuentran en su mayoría desactualizadas, se ha iniciado un proceso paulatino para hacer nuevas revisiones de los géneros de las tribus *Echiteae* y *Mesechiteae* que no hayan sido monografiados en los últimos años. Por el momento, esto ha producido la revisión total o parcial de varios grupos (e.g., Hansen 1985; Morales 1997 c, 1999 b, 2002 a, 2002 b, 2003; Williams 1998), la descripción de nuevos géneros (Morales 1999 a; Morales & Williams 2004; Williams 2002) y la publicación de varias nuevas especies. En el proceso de revisión del género *Prestonia*, se procedió a examinar la mayoría de colecciones tipos disponibles, tanto de especies descritas en ese género, como de aquellas ubicadas en otros diferentes (e.g., *Echites*), pero que han sido sinonimizadas a través del tiempo en *Prestonia*. *Echites blanchetii* fue descrito por Alphonse de Candolle (1844), basado en una colección hecha por Blanchet (3223 *a*) en 1840 en el estado de Bahia, Brasil. Este nombre fue reducido a la sinonimia de *Prestonia coalita* (Vell.) Woodson por Woodson (1936), quien probablemente nunca vió el tipo, ya que no citó dicha colección entre la lista de especímenes examinados. Luego de concluir la monografía de *Prestonia*, era claro que *Echites blanchetii* fue incorrectamente sinonimizado bajo *P. coalita* y que además no podía ser ubicado incluso en ese género, pues sus corolas carecían de estructuras coronales accesorias (i.e., corona anular alrededor de la fauce o corona epiestaminal, compuesta por cinco lóbulos coronales libres en forma opuesta a cada antera), uno de los principales caracteres diagnósticos de *Prestonia*. Ahora bien, mientras trabajaba en la elaboración de una nueva monografía para los géneros *Mandevilla* y *Mesechites*, noté que varias colecciones provenientes del estado de Bahia en Brasil, identificadas a través de los años como *M. mansoanus* (A. DC.) Woodson y morfológicamente algo similares a esa especie, tanto en la forma de las hojas, como en la estructura de la inflorescencia, tenían hojas eglandulares, careciendo

de coléteres en la superficie adaxial del nervio central. Aunque la presencia de coléteres en el nervio central es algo común para varios géneros de la tribu *Mesechiteae*, muy raramente algunas especies pueden carecer de coléteres (e.g., *Mandevilla angustifolia* (Malme) Woodson). Sin embargo, al proceder con el análisis de las flores, pude descubrir que la cabeza estigmática de este grupo de especímenes tiene forma de carrete de hilo, más angosta medialmente y con un anillo membranoso basal, sin costillas o crestas basales longitudinales, esto último un carácter diagnóstico que poseen el resto de miembros de la tribu *Mesechiteae*, a la cual pertenece *Mesechites* (Simões et al. 2004). Este material coincide en todos sus caracteres morfológicos con el tipo de *E. blanchetii*, así como a otras escasas colecciones depositadas en diferentes herbarios europeos. De esta manera, siguiendo a Endress & Bruyns (2000) y tomando el cuenta las características de la cabeza estigmática, estos especímenes pertenecen a la tribu *Echiteae*, pero no están relacionados con ninguno de los géneros hasta ahora conocidos dentro de esa tribu. Por lo tanto, un nuevo género se propone a continuación, incluida una descripción de sus caracteres morfológicos, con discusión de sus relaciones intergenéricas, una nueva combinación y la descripción de una nueva especie.

MORFOLOGÍA

Hábito y tallos

Las dos especies de *Bahiella* son lianas, con los tallos viejos conspicuamente leñosos. En forma general, las ramitas son algo aplanadas bajos los nudos cuando jóvenes, volviéndose teretes a subteretes con la edad. En algunos especímenes y en forma más rara, tallos jóvenes levemente angulados son encontrados. La secreción de las ramitas y otras partes de la planta al cortarse es blanca. En contraposición con especies de géneros de la tribu *Mesechiteae* (e.g., *Mandevilla*, *Mesechites*), donde los coléteres de los nudos pueden ayudarnos a reconocer ciertos grupos de especies, en *Bahiella* (así como en el resto de los géneros de la tribu *Echiteae*) los coléteres intrapeciolares son diminutos, fusiformes e inconspicuos y no tienen utilidad para distinción específica a nivel genérico.

Hojas

Las hojas son siempre pecioladas, no peltadas y eglandulares, sin coléteres en el nervio central adaxialmente, con la lámina conspicuamente coriácea, básicamente glabra y los márgenes conspicuamente revolutos marginalmente. En los demás miembros de la tribu *Echiteae*, es muy raro encontrar especies con los márgenes revolutos, estando limitados principalmente a *Hylaea* y ocasionalmente y en forma muy rara a unas pocas especies del género *Prestonia* y *Echites*. En forma general, solo la vena principal está impresa en ambas superficies, siendo las venas secundarias y terciarias usualmente no evidentes y no impresas.

Inflorescencias

Las inflorescencias son cimosas, axilares, ramificadas, con numerosas flores densamente aglomeradas en las partes distales de la inflorescencia, diminutamente puberulentas a glabrescentes, pedunculadas, con los pedicelos siempre conspicuos y evidentes. Las brácteas florales son siempre escariosas e inconspicuas y las bracteolas son ausentes. La presencia de bracteolas no es algo común en las Echiteae y está limitado a unos pocos géneros (e.g., *Macropharynx*, *Peltastes*).

Flores

El cáliz está compuesto por cinco sépalos escariosos e inconspicuos, con el ápice erecto o suberecto (no reflexo), los cuales albergan en la base de la cara adaxial un coléter solitario, irregular y profundamente lacerado apicalmente. En *Bahiella blanchetii*, los coléteres están algunas veces profundamente laciniados, por lo que erróneamente pueden ser tomados como una línea de coléteres individuales, como los presentes en el género *Peltastes*. Sin embargo, el grado de laceración de los coléteres no parece tener ninguna utilidad taxonómica, dado el alto nivel de variación intraespecífica presente en varios géneros de las Echiteae.

La forma de la corola varía de hipocrateriforma a infundibuliforma, glabra a inconspicuamente puberulenta exteriormente, sin estructuras coronales interiores (en forma de corona anular alrededor de la fauce o de una corona epiestaminal conformada por cinco lóbulos coronales libres en forma opuesta a cada antera). El limbo está conformado por cinco lóbulos, usualmente extendidos en la antesis, pero algo reflexos marginalmente, con estivación dextrosa. Los estambres están ubicados en la mitad distal del tubo y son totalmente incluidos, con las anteras glabras dorsalmente, fuertemente aglutinadas a la cabeza estigmática en dos puntos, con sus bases estériles y sagitadas, con cada aurícula conspicuamente acuminada.

El ovario es apocárpico y está conformado por dos carpelos, glabros y unidos apicalmente al estilo, cada carpelo con numerosos óvulos. La cabeza estigmática tiene forma de carrete de hilo, relativamente fusiforme, con un conspicuo anillo membranoso en la base, siendo mucho más ancha en su parte basal. El nectario es anular, pero con el borde superior irregularmente pentalobulado. La lobulación del nectario puede ser muy leve y casi no evidente o estar dividido en lóbulos relativamente bien marcados, incluso en el mismo especimen. Este tipo de variación intraespecífica no es algo raro en las Echiteae, ya que tal y como se ha comentado en forma previa (Morales 2004), el grado de lobulación del nectario puede ser muy alto es algunos géneros y por lo tanto, es un carácter que debe utilizarse con reserva a nivel de distinción interespecífico.

Frutos y semillas

Los frutos están compuestos por dos folículos, relativamente divaricados, continuos y glabros, libres, continuos, secos y levemente leñosos al secar, con

diminutas costillas o protuberancias longitudinales. Folículos divaricados tampoco son comunes en las *Echiteae*, estando presentes en unos pocos miembros de unos cuantos géneros (e.g., *Echites*, *Prestonia*, *Stipecoma*). Las semillas son numerosas, secas, glabras, comosas apicalmente y como muchos otros miembros de las *Echiteae*, son conspicuamente rostradas, con el rostro delgado.

MATERIALES Y MÉTODOS

Con el fin de determinar las posibles relaciones intergénericas de *Bahiella*, un total de 44 especies pertenecientes a 19 géneros de la tribu Echiteae (sensu Endress & Bruyns 2000) con distribución restringida al Nuevo Mundo, fueron incluidos en un análisis cladístico. Como grupos externos fueron escogidos dos representantes de las tribu Apocyneae (*Beaumontia*, *Odontadenia*) y seis de la Mesechiteae (*Allomarkgrafia*, *Tintinnabularia*, *Mandevilla*), basado en estudios moleculares previos (e.g., Sennblad et al. 1998; Sennblad & Bremen 2002) que han sugerido las relaciones cercanas de Echiteae con esas tribus. Finalmente se utilizaron dos representantes de las Malouetieae (*Pachypodium*) con el objeto de enraizar el árbol.

Cincuenta y seis caracteres representado ciento treinta y un estados fueron evaluados para cada uno de las especies (Tabla 1). Algunos caracteres fueron seleccionados de estudios previos (Endress et al. 1996; Simões et al. 2004; Williams 2002, 2004), mientras que otros son incluidos por primera vez. Los estados de caracteres fueron evaluados en especimenes de herbario, flores preservadas y material fresco cuando estuviera disponible, los que a su vez fueron corroborados en forma paralela con descripciones de literatura (Morales 1997 a, 1997 c, 1997 d, 1999 a, 2002 a, 2002 b, 2005 a, 2005 b; Morales & Williams 2004; Williams 1998, 2002; Woodson 1933, 1936). La explicación de los caracteres que no hayan sido utilizados anteriormente en análisis cladísticos previos, así como algunas discrepancias encontradas entre lo citado en la literatura y lo presente en los especimenes son brindados en el apéndice 1.

Los caracteres morfológicos evaluados fueron organizados en una matriz (Tabla 1) utilizando Winclada, version 1.00.08 (Nixon 2002). Todos los caracteres fueron tratados con un mismo peso y en forma desordenada. Especies con caracteres multiestados fueron reconocidos como polimórficos. El análisis heurístico incluyó una ronda de 500 replicaciones de secuencia y adición aleatoria, con la opción "Multi TBR + TBR" seleccionada y con un máximo de 10000 árboles a mantener, salvando un árbol por réplica. El soporte relativo de los nudos del árbol de mayor consenso estricto fue obtenido mediante el procedimiento de "bootstrap" implementado en Winclada, con un número total de 1000 réplicas, 10 réplicas de búsqueda aleatoria para secuencias adicionales, un árbol conservado en cada réplica y con la opción "TBR" activada, salvando un máximo de 100 árboles en cada réplica.

TABLA 1. Matriz de datos morfológicos de 56 caracteres usados en el análisis cladístico.

Especie	Estados de caracter											
	0	5	10	15	20	25	30	35	40	45	50	55
Pachypodium lamerei	20010	00000	00010	10210	00-00	00001	42110	30010	00000	00-00	01011	1
Pachypodium geayi	20010	00000	a0010	10210	00-00	00001	42110	30010	00000	00 00	01011	1
Beaumontia grandiflora	01010	10000	00011	10211	01121	00001	41110	30210	00010	21-00	01011	1
Odontadenia matogrossana	01010	10001	00001	10210	01221	00001	02110	31110	00010	21-00	01111	1
Tintinnabularia gratissima	01010	11101	00011	00200	01222	00001	11110	21110	01012	32001	00111	1
Tintinnabularia mortonii	01010	11101	00011	00200	01222	00001	11110	21210	01012	32001	0????	?
Alllomarkgrafia brenesiana	01010	11001	00000	00210	00221	00001	42110	21110	00012	32001	01111	1
Allomarkgrafia plumeriifolia	01010	11001	00000	00210	00221	00001	42110	b1110	00012	32001	01111	1
Mandevilla hirsuta	01010	11001	00011	00011	01011	10001	02110	21110	00012	32100	00111	1
Mandevilla sagittarii	01010	11001	00011	00011	01011	10001	02110	21110	00012	32100	00111	1
Allotoonia turbinata	01110	10001	00111	00210	00010	00001	30100	00110	00010	10-11	01110	1
Allotoonia woodsoniana	01110	10001	0a111	00210	00010	00001	20100	00110	00010	10 11	01110	1
Angadenia berterii	01010	10001	00a11	00110	00222	00001	02110	b1110	00010	10 11	01110	0
Angadenia lindeniana	01010	10001	00a11	00110	00222	00001	02110	21110	00010	10-11	01110	0
Asketantnera calycosa	01010	10001	00011	00111	01010	00000	42110	11110	00010	10-11	01110	1
Asketantnera dolichopetala	01010	10001	00011	00111	01010	00000	42110	11110	00010	10 11	?????	?
Asketantnera ekmanniana	01010	10001	00011	00111	01010	00000	32110	31110	00010	10-11	?????	?
Bahiella blanchetii	01010	10000	11111	00210	00010	00001	b2110	11110	00010	10 10	01100	1
Bahiella infundibuliflora	01010	10000	11111	00210	00011	00001	32110	11110	00010	10-10	?????	?
Cycladenia humilis	11?00	10001	00111	00110	00 01	00001	12110	11110	00010	10-10	01111	1
Echites umbellata	01110	10001	00011	00100	00010	00001	42110	c1110	00011	10-11	01110	1
Echites yucatanensis	01110	10001	00011	00b10	00010	00001	42110	c1110	00011	10-1a	01110	1
Fernaldia asperoglottis	01010	10001	00011	00110	00011	00001	42111	b1110	00011	10-10	01110	1
Fernaldia pandurata	01010	10001	00011	00110	00011	10001	42111	b1110	00011	10 10	01110	1
Fernaldia speciosissima	01010	10001	00011	00110	00011	00001	42111	31110	00011	10-10	01110	1
Hylaea arborescens	21110	10000	11111	00210	00010	00011	42110	10112	00010	10-11	?????	?
Hylaea leptoloba	01110	10000	11111	00210	00010	00011	42110	10112	00010	10-11	?????	?
Laubertia boissieri	01110	10001	00011	00210	00-00	01101	22110	10111	00010	10 11	00111	0
Laubertia contorta	01110	10001	00011	00110	00-00	01101	22110	10111	00010	10-11	00111	1

Tabla 1. continued

Especie	Estados de caracter											
	0	5	10	15	20	25	30	35	40	45	50	55
Macropharynx renteriae	01110	10001	00111	01211	11010	00001	42110	21110	00010	10-11	01010	1
Macropharynx spectabilis	01110	10001	00111	01211	11011	00001	42110	c1110	00010	10-11	01010	1
Neobracea bahamensis	21?10	10000	10001	10210	00-01	00001	42110	01110	00010	10-11	01111	1
Neobracea ekmanii	21?10	10000	10001	10110	00-01	00001	12110	01110	00010	10-11	01111	1
Peltastes isthmicus	01110	10011	00111	01211	11121	00001	32110	31110	00010	10-11	01010	1
Peltastes peltatus	01110	10011	00111	01211	11121	00001	42110	b1110	00010	10-11	01010	1
Peltastes peruvianus	01110	10011	00111	01211	11121	00001	32110	31110	00010	10-11	01010	1
Pentalinon andrieuxii	01010	10001	00001	00110	00122	00001	02110	31110	01110	10-10	01110	0
Pentalinon luteum	01010	10001	00001	00111	00122	00001	02110	c1110	01110	10-11	01110	0
Prestonia falcatosepala	01110	10001	00111	00110	01010	01111	42110	10111	00010	10-10	11111	1
Prestonia quinquangularis	01010	10001	a0111	00110	00010	01101	42110	10111	00010	10-11	11111	1
Prestonia ipomaeifolia	01010	10001	00001	00201	01010	01111	42110	10111	00010	10-10	01011	1
Prestonia longifolia	01110	10000	00001	00210	00010	01111	42110	10111	00010	10-10	01111	1
Prestonia vana	01010	10000	00001	00211	01010	01111	42110	10111	00010	10-11	01001	1
Rhabdadenia biflora	01010	10001	00111	00100	01-01	00001	42110	31110	10010	10-11	01110	0
Rhabdadenia macrostoma	a1010	10001	00111	00100	0a-01	00001	b2110	c1110	10010	10-11	01110	0
Rhabdadenia ragonesei	01010	10001	00111	00100	01-01	00001	12110	31110	10010	10-11	01110	0
Stipecoma peltigera	01011	10010	00011	00010	00220	00001	12110	10110	00010	10-11	01110	0
Temnadenia stenantha	01110	10001	00111	00210	00010	00001	42110	20110	00010	10-11	?????	?
Temnadenia odorifera	01110	10001	00111	00210	00010	00001	42110	20110	00010	10-1a	11110	1
Thenardia chiapensis	01110	10001	00111	00100	00014	00001	41110	00102	00010	10-11	10110	1
Thenardia floribunda	01110	10001	00111	00200	00014	00001	21110	00102	00010	10-11	10110	1
Thenardia galeottiana	01110	10001	00111	00200	00014	00001	41110	00102	00010	10-11	10110	1
Thoreauea aberrans	01010	10001	00111	00200	00012	00101	41010	00100	00010	10-11	?????	?
Thoreauea paneroi	01010	10001	00011	00200	00013	00101	41010	00100	00010	10-11	?????	?

Caracteres polimórficos representados por letras de acuerdo a la siguiente disposición:
a = 0/1, b = 1/2, c – 2/3
? = datos desconocidos.

RESULTADOS

Un total de 45 árboles parsimoniosos de 184 pasos fueron obtenidos por el análisis heurístico, con un índice de consistencia de 0.4 y un índice de retención de 0.75. El árbol de mayor consenso estricto, así como los valores de "bootstrap" mayores o iguales a 50 son presentados en la Figura 1. En general, al igual que otros análisis cladísticos basados únicamente en datos morfológicos que han involucrado miembros de las Echiteae y Mesechiteae (e.g., Simões et al. 2004; Williams 2004) el soporte de los clados basales es bajo y una gran politomía prevalece; solamente algunos clados y subclados terminales están soportados con valores de "bootstrap" mayores a 50%. Por lo tanto, la discusión subsecuente se orientará a comentar la conformación de los clados y subclados del árbol de mayor consenso estricto.

En primera instancia es interesante la posición de *Neobracea* sugerida en este cladograma. Este género ha sido tradicionalmente ubicado dentro de las Echiteae, pero acá aparece ubicado en un subclado relacionado con el grupo externo y no con el interno (las Echiteae). Aunque el propósito de este análisis no es probar la monofilia de las Echiteae, la ubicación de *Neobracea* sugiere la necesidad de evaluar la monofilia de la tribu tal y como se encuentra conformada en la actualidad (según Endress & Bruyns 2000).

Dentro del grupo interno, el primer clado está conformado por los géneros *Stipecoma*, *Cycladenia*, *Rhabdadenia*, *Angadenia* y *Pentalinon*, dentro del cual *Cycladenia* y *Rhabdadenia* conforman un subclado y *Angadenia* y *Pentalinon* otro subclado. Esta misma relación entre *Angadenia* y *Pentalinon*, había sido sugerida anteriormente por Williams (2004), quién obtuvo resultados similares en un análisis orientado a determinar la monofilia del género *Echites*.

El siguiente clado está conformado por 4 subclados que conforman una gran politomía sin resolver. Un total de 4 subclados son reconocidos: el subclado de *Fernaldia*, el subclado de *Asketanthera*, el subclado de *Echites* y el último de ellos conformado por 10 géneros, que a su vez se encuentran agrupados en algunos subclados: *Temnadenia*, *Allotoonia*, el subclado de *Bahiella* y *Hylaea*, el subclado de *Macropharynx* y *Peltastes*, el subclado de *Thoreauea* y *Thenardia* y el subclado de *Prestonia* y *Laubertia*. Sin embargo, a pesar de que los resultados sugieren que *Bahiella* está relacionada con el resto de las Echiteae, basado en el bajo soporte de los clados basales y la gran politomía sin resolver prevaleciente, no es posible determinar por el momento y de manera concisa los géneros más cercanamente relacionados con *Bahiella*. Partiendo de los resultados sugeridos por este análisis, es claro que son necesarios estudios moleculares complementarios para definir apropiadamente las relaciones intergénericas dentro de las Echiteae, así como para probar la monofilia de la tribu. Análisis filogenéticos basados en caracteres morfológicos en otras tribus de las Apocynoideae (e.g., Mesechiteae), han resultado en cladogramas pobremente resueltos, en contraposición con análisis basados en estudios moleculares (o

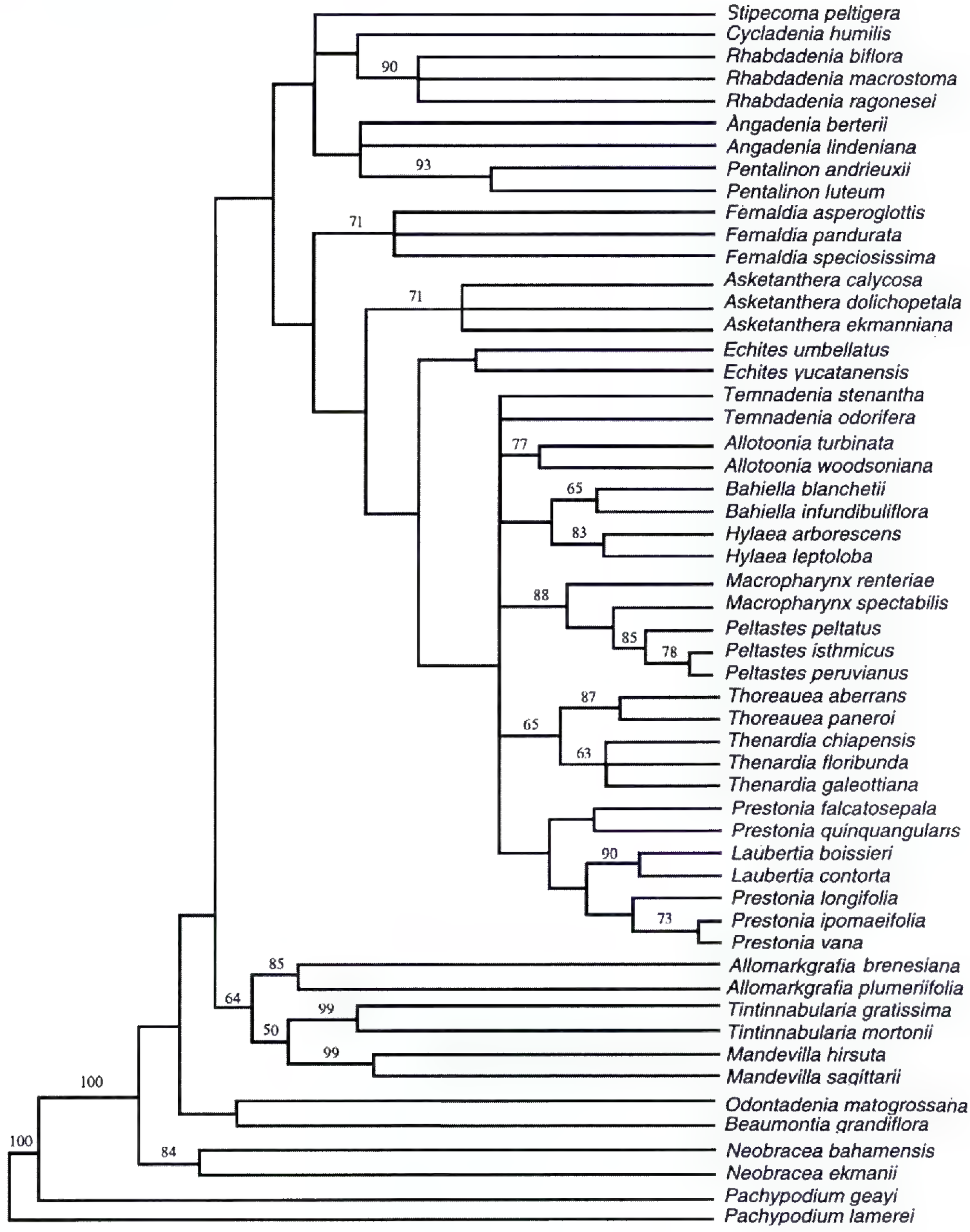


Fig. 1. Árbol de mayor consenso estricto calculado de los 45 árboles más parsimoniosos. Valores de "bootstrap" mayores o igual a 50 son indicados sobre las ramas.

combinados), que han propuesto cladogramas con mucho más soporte (Simoes et al. 2004). En todo caso, los resultados de esos mismos estudios han conllevado a la necesidad de variar la configuración original propuesta por Endress & Bruyns (2000) para conformar tribus naturales y monofiléticas. Sin embargo, aún falta trabajo para determinar la conformación definitiva de otras (e.g.,

Apocyneae), dado que se ha determinado que su constitución actual no es monofilética.

TRATAMIENTO TAXONÓMICO

Bahiella J.F. Morales, gen. nov. TIPO: *Bahiella blanchetii* (A. DC.) J.F. Morales.

Fruticosa volubilis; folia opposita petiolata, coriacea, eglanduligera, revoluta; inflorescentia corymbosa, lateralis, pedunculata, multiflora; corolla regularis 5-partita, infundibuliformis vel hypocraterimorpha, corona et coronae lobis absens, antheris sagitattis, basi acuminata. Fructus folliculis divaricatus.

Lianas con tallos viejos leñosos, con secreción lechosa al cortarse, las ramitas jóvenes usualmente teretes a subteretes, algo aplanadas en los nudos, más raramente anguladas, coléteres intrapeciolares inconspicuos. Hojas opuestas, pecioladas, sin coléteres en el nervio central adaxialmente, sin domacios abaxialmente. Inflorescencias cimosas, axilares, pedunculadas, con muchas flores, densamente aglomeradas distalmente, el raquis usualmente noduloso, brácteas florales escariosas, bracteolas ausentes; sépalos escariosos, con un coléter solitario, episépalo, dispuesto en la base de la cara adaxial, usualmente profunda e irregularmente lacerado, a veces casi totalmente dividido en varios segmentos; corola infundibuliforme o hipocrateriforma, glabra, glabrescente o inconspicuamente puberulenta exteriormente, sin estructuras coronales interiormente, el limbo actinomórfico, dextrorsamente convoluto, estambres incluidos, las anteras conniventes y aglutinadas en dos puntos a la cabeza estigmática, las bases estériles conspicuamente acuminadas y sagitadas, ovario bicarpelar, los carpelos unidos en forma apical al estilo, los óvulos numerosos, la cabeza estigmática fusiforme, con un anillo membranoso basalmente, nectario anular, irregularmente pentalobulado. Frutos apocárpicos, compuestos por dos folículos, más o menos divaricados, continuos, glabros, con diminutas costillas longitudinales; semillas numerosas, secas, rostradas, glabras, comosas apicalmente.

Bahiella es un género de dos especies, endémico a las formaciones costeñas del estado del Bahia, Brasil. Su nombre genérico hace referencia al estado de Bahia, Brasil, la única localidad conocida por el momento.

CLAVE PARA LAS ESPECIES DE *BAHIELLA*

1. Corola hipocrateriforma, con la fauce de 2,5–3,5 mm de diámetro; lóbulos de la corola de 7–11 × 4–6 mm; anteras de 5,5 6 mm de largo; sépalos de 1–1,3 × 1 1,2 mm _____ **B. blanchetii** (A. DC.) J.F. Morales

1. Corola infundibuliforme, con la fauce de 9–10 mm de diámetro; lóbulos de la corola de 14–16 × 10–13 mm; anteras de 7–7,5 mm de largo; sépalos de 2,2–3 × 1,9–2,6 mm _____ **B. infundibuliflora** J.F. Morales

1. Bahiella blanchetii (A. DC.) J.F. Morales, comb. nov. (**Fig. 2**). BASIÓNIMO: *Echites blanchetii* A. DC., Prodr. 8:448. 1844. *Mitozus blanchetii* (A. DC.) Miers, Apocyn. S. Amer. 219. 1878. TIPO: BRASIL. BAHIA: Bahia, 1840 (fl), *Blanchet 3223a* (HOLOTIPO: G-DC, foto F neg. 7567, INB).

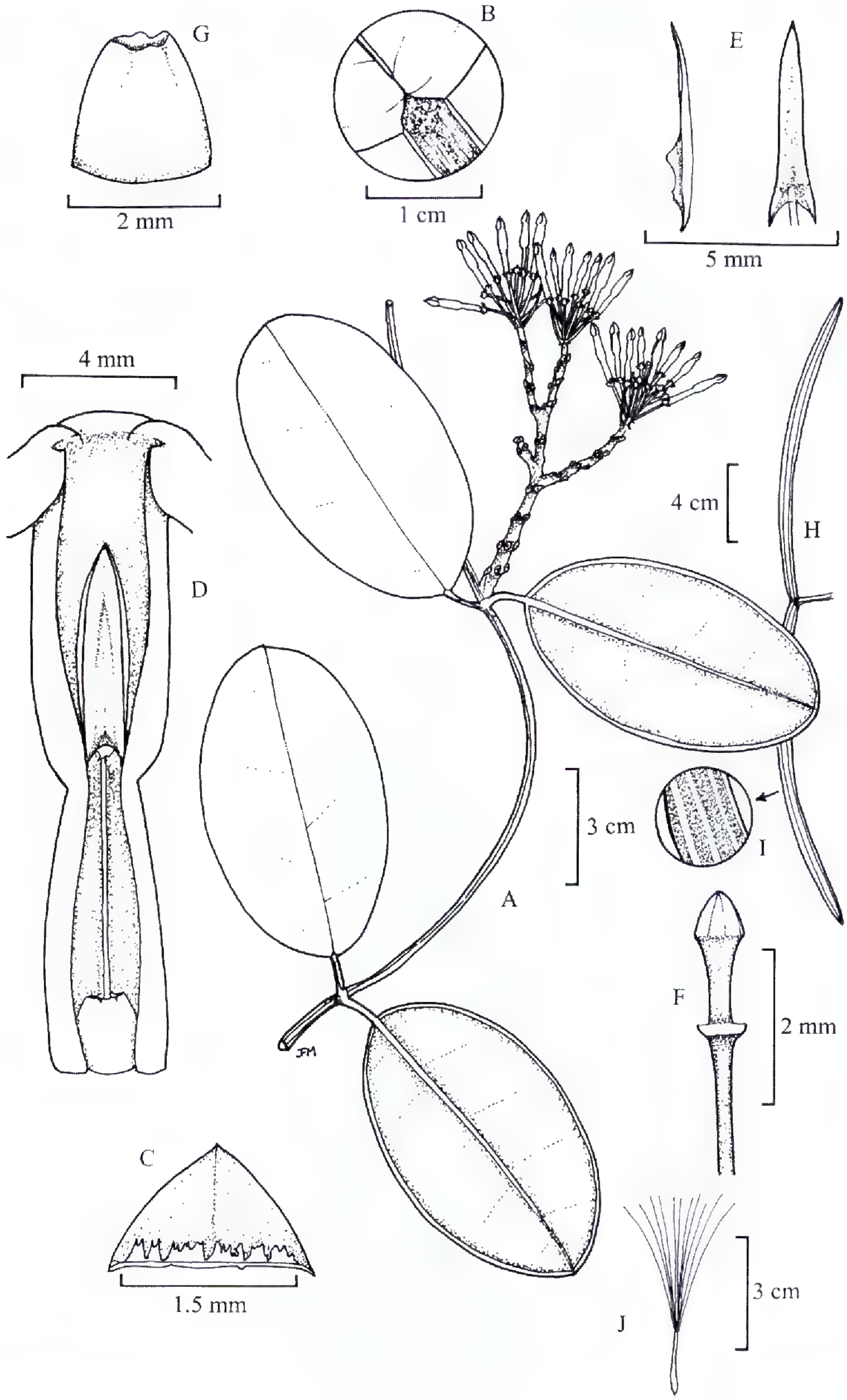


FIG. 2 *Bahiella blanchetii* (A–G de *Santos 2219*, CEPEC; H–J de *Amorin et al. 1386*, CEPEC). **A.** Ramita con inflorescencia. **B.** Detalle de la base adaxial de la lámina foliar, mostrando la ausencia de coléteres. **C.** Vista adaxial de un sépalo, mostrando el coléter en la base. **D.** Tubo de la corola longitudinalmente abierto, mostrando las anteras, estilo y nectario. **E.** Antera, vista dorsal y lateral. **F.** Cabeza estigmática. **G.** Nectario. **H.** Folículos. **I.** Detalle de las crestas de los folículos. **J.** Semilla.

Liana, los tallos viejos leñosos, ramitas usualmente teretes a subteretes, glabras a glabrescentes, coléteres interpeciolares ca. 1 mm de largo. **Hojas:** pecíolos de 6–13 mm de largo; láminas de 8–16,5 × 4,5–7,5 cm, coriáceas a subcoriáceas, elípticas a obovadas u obovado-elípticas, redondeadas, obtusas a inconspicuamente retusas o apiculadas apicalmente, redondeadas, obtusas a raramente cuneadas basalmente, usualmente conspicuamente revolutas marginalmente cuando viejas, esencialmente glabras, eglandulares, sin coléteres en el nervio central adaxialmente, la venación secundaria apenas evidente o inconspicua en ambas superficies, la venación terciaria no evidente. Inflorescencias inconspicua y esparcidamente puberulentas a glabrescentes, pedúnculo 4–65(–100) mm de largo, el raquis conspicuamente noduloso, pedicelos de 12–25 mm de largo, brácteas de 0,5–1 × 0,5 mm, escariosas, sépalos de 1–1,3 × 1–1,2 mm, levemente imbricados basalmente, angostamente ovados, agudos a obtusos apicalmente, muy esparcida e inconspicuamente puberulentos a glabrescentes exteriormente, coléteres menos de 0,5 mm de largo, irregularmente lacerados; corola hipocrateriforma, el tubo púrpura intenso, rosado a rojizo, los lóbulos lila a rojizos, pero blanquecinos marginalmente, glabra, glabrescente a inconspicua y esparcidamente puberulenta exteriormente, tubo de 15–17 mm de largo, de 2,5–3,5(–4) mm de diámetro en el orificio, inflado sobre la posición de los estambres, lóbulos de 7–11 × 4–6 mm, angostamente obovados, extendidos pero variadamente reflexos marginalmente; anteras de 5,5–6 mm de largo, glabras dorsalmente, cabeza estigmática de 1,5–1,75 mm de largo; ovario de 1–2 mm de largo, glabro, nectario ca 1,6–2 mm de largo, anular, leve e irregularmente pentalobulado. Frutos compuestos por dos folículos apocárpicos, de 14–19 × 0,5–0,7 cm, más o menos divaricados, glabros, continuos, con numerosas costillas longitudinales e inconspicuas; semillas de15–20 mm de largo, coma apical de 2,8–4 cm de largo, color canela.

Distribución, habitat y ecología.—Endémica del estado de Bahia, Brasil, donde se encuentra en bosques húmedos, vegetación costera, vegetación de restinga, y áreas de vegetación alterada asociada, en elevaciones de 0–100 m. Especímenes con flores han sido recolectados entre enero y febrero y de septiembre a noviembre. Material con frutos se reporta en enero, febrero, septiembre y noviembre.

Bahiella blanchetii es una especie aparentemente común, que se reconoce al instante por sus flores con corolas hipocrateriformas. Es interesante notar como este género y en particular esta especie, la cual fue descrita desde hace más de 150 años, ha permanecido desapercibida desde entonces. En forma general, pocos taxónomos vieron el tipo, pues ni Miers (1878) ni Woodson (1936) lo examinaron y aparentemente solo Müller Argoviensis (1860) lo hizo, pero en todo caso lo trató en el entonces inclusivo género *Echites*. En todo caso, las colecciones disponibles antes de 1970 eran muy escasas y prácticamente esta especie se conocía solo por el tipo y dos colecciones adicionales hechas por Regel

y Riedel, ambas sin localidad ni fecha exacta y depositada en el herbario de la Universidad de Cambridge, Inglaterra (CGE) y en el Museo de Historia Natural de Viena (W). La semejanza de esta taxón con un *Mesechites* (i.e., *Mesechites mansoanun* (A. DC.) Woodson) es muy notable, ya que ambas especies son morfológicamente muy similares; inclusive, el especimen depositado en Viena fue examinado por Woodson y catalogado como *M. mansoanus*; sin embargo, como se explicó anteriormente, las características de la cabeza estigmática de ambas géneros son bien distintas y excluyentes, así como otros caracteres morfológicos adicionales. En los últimos 30 años el incremento de la actividad botánica en Bahia, ha aumentado considerablemente el número de especímenes disponibles hoy en día, lo que ha permitido determinar en forma definitiva, el estatus genérico de esta especie.

Especímenes examinados. **BRASIL. Bahia:** Ilhéus, Fazenda Jaguariba, al O de carretera Ilhéus-Olivença, 31 Ene 1997 (fl), *Arbo et al. 7835* (CEPEC, CTES); Una, reserva biológica do Mico-leão (IBAMA), entre Ilhéus y Una, 14 Sep 1993 (fl, fr), *Amorin et al. 1386* (CEPEC); Maraú, carretera BR 030, entre Ubaitaba y Maraú, 25 Feb 1980 (fl, fr), *Carvalho et al. 166* (CEPEC); Cabralia, reserva biológica DO Pau-Brasil, 5 Ene 1972 (fl, fr), *Eupunino 126* (CEPEC); S de Cumuruxatiba, camino a Prado, 18 Ene 1977 (fl), *Harley 18089* (CEPEC, K, Z); entre Una y Ilhéus, 23 Ene 1977 (fl), *Harley et al. 18178* (CEPEC, INB, K, NY); Santa Cruz de Cabrália, carretera antigua, 21 Oct 1978 (fl), *Mori et al. 10919* (CEPEC, NY); Maraú, 25 Nov 1971 (fl, fr), *Santos 2219* (CEPEC); Valença, entre Valença y Guaibim, 21 Feb 1975 (fl, fr), *Santos 2888* (CEPEC); Itacaré, N de Serra Grande, camino a Itacaré, 15 Nov 1992 (fl), *Thomas et al. 9507* (CEPEC, NY, USF). **Datos perdidos:** (fl), *Regel s.n.* (CGE); (fl), *Riedel s.n.* (U, W).

2. Bahiella infundibuliflora J.F. Morales, sp. nov. (**Fig. 3**). TIPO: BRASIL. BAHIA: Ilhéus, NNE de Banco da Vitoria (5.7 km al O del puente sobre el río Fundão, camino a Itabuna), en camino al sector O de Mata da Esperança, 15 Ene 1995 (fl), *Thomas et al. 10765* (HOLOTIPO: CEPEC).

A *B. blanchetii* (A. DC.) J.F. Morales, cui affinis, corollae infundibuliformis, lobis 14–16 mm longis, et antheris 7–7,5 mm longis differt.

Liana, los tallos viejos leñosos, ramitas usualmente teretes a subteretes, glabras a glabrescentes, coléteres interpeciolares ca. 1 mm de largo. **Hojas:** pecíolos de 5–8 mm de largo; láminas de 8–16,5 × 3,8–5,5 cm, subcoriáceas, elípticas a obovado-elípticas, obtuso-apiculadas apicalmente, obtusas y cortamente atenuadas basalmente, revolutas marginalmente cuando viejas, glabras, eglandulares, sin coléteres en el nervio central adaxialmente, la venación secundaria apenas evidente en ambas superficies, la venación terciaria no evidente. Inflorescencias diminuta y esparcida a moderadamente papilado-puberulentas, pedúnculo de 95–96 mm de largo, el raquis inconspicuamente noduloso, pedicelos de 10–13 mm de largo, brácteas de 1–1,5 × 0,5–1 mm, escariosas, sépalos de 2,2–3 × 1,9–2,6 mm, levemente imbricados basalmente, angostamente ovados, agudos o cortamente acuminados apicalmente, esparcida a moderadamente puberulentos exteriormente, más raramente glabrescentes, coléteres ca. 1 mm de largo, irregular y profundamente lacerados; corola infundibuliforme, magenta basalmente, con los lóbulos verde pálido, glabra,

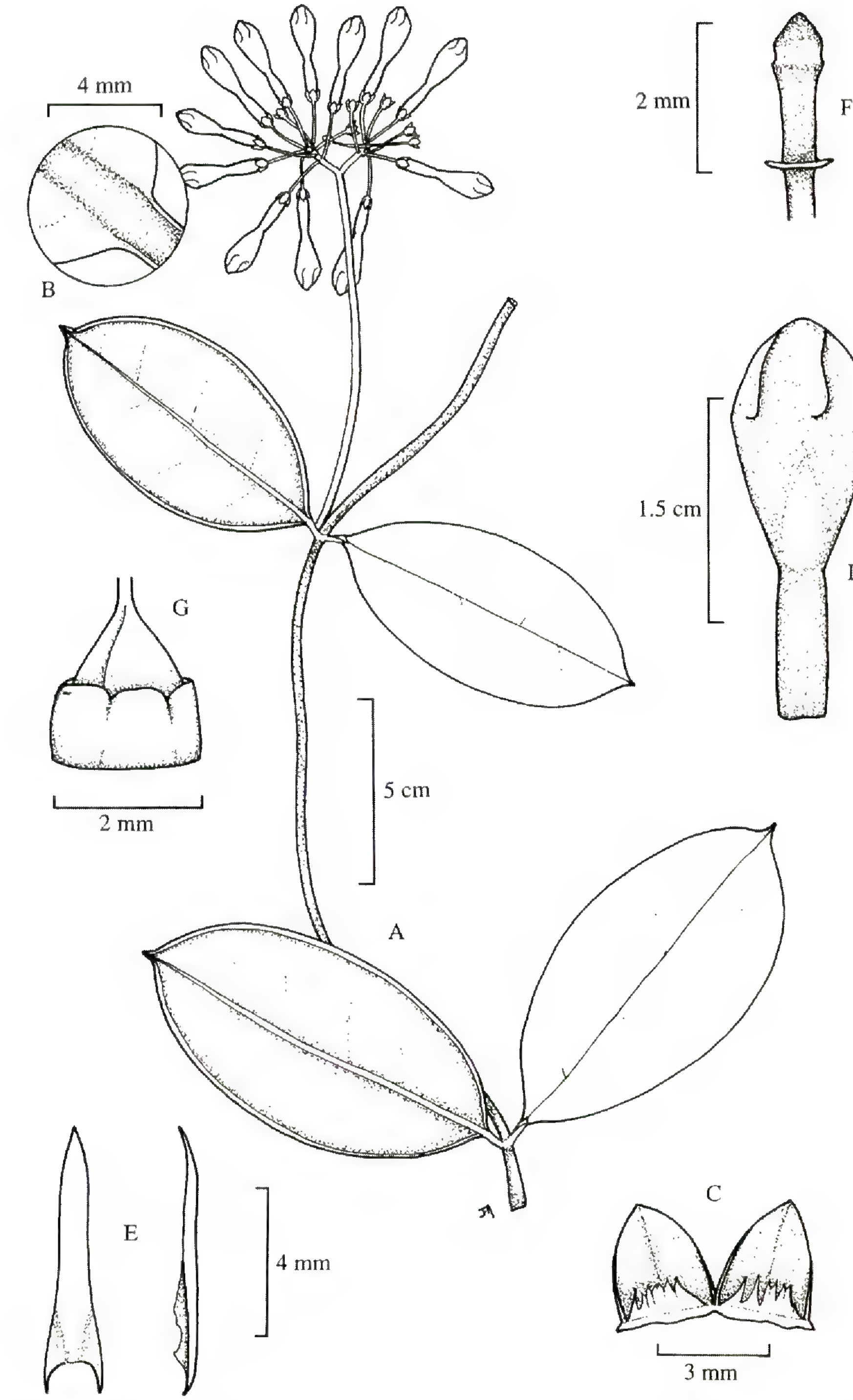


FIG. 3. *Bahiella infundibuliflora* (*Thomas et al. 10765*, CEPEC). **A.** Ramita con inflorescencia. **B.** Detalle de la base adaxial de la lámina foliar, mostrando la ausencia de coléteres. **C.** Vista adaxial de dos sépalos, mostrando los coléteres en la base. **D.** Detalle del tubo de la corola. **E.** Antera, vista dorsal y lateral. **F.** Cabeza estigmática. **G.** Ovario y nectario.

glabrescente a inconspicua y esparcidamente puberulenta exteriormente, la parte inferior del tubo de 10–12 × 2,7–3,2 mm, recto, la parte superior de 10–12 mm de largo, de 9–10 mm de diámetro en la fauce, lóbulos de 14–16 × 10–13 mm, obovados, extendidos pero variadamente reflexos marginalmente; anteras de 7–7,5 mm de largo, glabras dorsalmente, cabeza estigmática de 2–2,2 mm de largo; ovario de 1,8–2,1 mm de largo, glabro, nectario de 1–1,3 mm de largo, anular, leve a moderadamente pentalobulado. Folículos desconocidos.

Distribución, habitat y ecología.—*Bahiella infundibuliflora* es conocida únicamente de la localidad tipo, donde crece en bosques húmedos y márgenes de bosques, en elevaciones bajo 50 m. El único especimen con flores conocido fue recolectado en enero.

Bahiella infundibuliflora es morfológicamente muy similar a *B. blanchetii* y aunque de primera instancia, ambas especies pueden confundirse, se pueden diferenciar con facilidad. De esta manera, *B. infundibuliflora* se puede distinguir fácilmente por su corola infundibuliforme (vs. hipocrateriforma), con la fauce del tubo de 9–10 mm de ancho (vs. 2,5–3,5(–4) mm), sépalos más largos y anchos, anteras de 7–7,5 mm de largo (vs. 5,5–6 mm de largo) y lóbulos de la corola mucho más grandes y desarrollados, de 14–16 × 10–13 mm (vs. 7–11 × 4–6 mm).

APÉNDICE 1
CARACTERES Y ESTADOS DE CARÁCTER UTILIZADOS EN EL ANÁLISIS CLADÍSTICO, CON ALGUNAS NOTAS EXPLICATORIAS

A continuación se citan los caracteres y estados de carácter utilizados en el análisis cladístico. Notas explicatorias son incluidas para aquellos que sea necesario, así como cuando se hayan encontrado discrepancias entre lo citado por la literatura y lo encontrado entre los especimenes. Los caracteres 1, 3, 7, 8, 20, 23, 26, 38, 44, 45, 46, 47, 48, 49, fueron tratados por Simões et al. (2004), mientras que el 12, 13, 14, 16, 28, 29, 36, 40, 50, 52, 53, 55 por Williams (2004). Por lo tanto, no serán explicados aquí.

1. **Hábito**
   0 Liana o hierbas escandentes
   1 Hierba perennes
   2 Árboles o arbustos
2. **Tallos con espinas**
   0 Sí
   1 No
   En general los miembros de las Echiteae y Mesechiteae no tienen espinas o aguijones en el tallo, pero este en un carácter que se presenta en forma ocasional en géneros de otrasa tribus (e.g., Malouetieae).
3. **Látex**
   0 Lechoso
   1 Acuoso
4. **Tallos inferiores**
   0 Herbáceos, no lignificados
   1 Variadamente lignificados
   Casi sin excepción, la mayoría de los miembros neotropicales de las Echiteae o Mesechiteae son lianas, con los tallos viejos variadamente leñosos, algunos veces con la corteza conspicuamente suberosa. Sin embargo, *Cycladenia* es una hierba erecta o suberecta, que se caracteriza por sus tallos herbáceos, no leñosos (Woodson 1936).
5. **Yemas axilares cubiertas por grupos de coléteres filiformes**
   0 No
   1 Sí

En general, la pubescencia de los tallos y brotes jóvenes de las Apocynaceae es muy variable, pero en las Echiteae únicamente en *Stipecoma* se da la presencia de coléteres filiformes envolviendo las yemas axilares

6. Filotaxia
0 Alternas
1 Opuestas

7. Hojas con coléteres en nervio central
0 No
1 Sí

8. Hojas con domacios
0 No
1 Sí

9. Hojas peltadas
0 Ausentes
1 Presentes

10. Consistencia de las hojas
0 Coriáceas
1 Membranáceas

11. Márgenes revolutos
0 Ausentes
1 Presentes

12. Venas secundarias impresas
0 Sí
1 No

13. Venación terciaria en la cara abaxial
0 Conspicua, bien impresa
1 Inconspicua, apenas impresa o no impresa

14. Venas terciarias finamente reticuladas
0 Sí
1 No

15. Venas terciarias perpendiculares al nervio central
0 Sí
1 No
Las venas terciarias cuando presentes, tienen patrones irregulares en cuanto a su disposición, pero en pocos géneros (e.g., *Allomarkgrafia*) están dispuestas de manera más o menos perpendicular en relación al nervio central.

16. Posición de la inflorescencia
0 Axilar
1 Terminal

17. Numero de inflorescencias por nudo
0 Una sola inflorescencia en alguna de las dos axilas
1 Dos inflorescencias, una en cada axila
En forma general, de igual manera que se presenta en otras tribus relacionadas (e.g., Mesechiteae), los miembros de las Echiteae tienen una sola inflorescencia por nudo, pero en unos pocos géneros (e.g., *Macropharynx*, *Peltastes*), dos inflorescencias por nudo usualmente están presentes.

18. Tipo de inflorescencia
0 Racimo
1 Cima sin ramificar o con una sola división basal
2 Cima ramificada
Williams (2004) mencionó que las inflorescencias en *Laubertia contorta* (M. Martens & Galeotti) Woodson no son ramificadas, pero en realidad inflorescencias con al menos una ramificación también son encontradas en esta especie, por lo que este estado de carácter debe tratarse como polimorfico.

19. Flores aglomeradas con aspecto umbeliforme
0 Sí
1 No

20. Brácteas
0 Escariosas, inconspicuas
1 Foliáceas, conspicuas

21. Bracteolas
0 Ausentes
1 Presentes
La presencia de bracteolas es raro en las Echiteae y Mesechiteae, presentándose principalmente en *Macropharynx* y *Peltastes*, aunque si bien, bracteolas inconspicuas pueden presentarse en unas pocas especies de *Mandevilla* o *Neobracea*.

22. Consistencia de los sépalos
0 Escariosos
1 Foliáceos o subfoliáceos

23. Disposición de los coléteres
0 Solitarios y epicentricos
1 Filas continuas e irregulares en la base
2 Alternos con los sépalos
Woodson (1936), en su monografía de *Pentalinon* (tratado entonces como *Urechites*) mencionó que los coléteres en *P. andrieuxii* (Müll. Arg.) B. Hansen & Wunderlin eran alternos con los sépalos, pero la evaluación de dicho carácter en diferentes

especimenes han revelado que estos se encuentran distribuidos de manera continua en una hilera de forma irregular a lo largo de la base del sépalo.

24. Número de coléteres por cáliz

0 Cero
1 Cinco
2 Seis ó mas

25. Forma de la corola

0 Hipocrateriforme
1 Infundibuliforme, parte superior cónica o tubular
2 Infundibuliforme, parte superior campanulada
3 Urceolada
4 Rotada

Tanto Simões et al. (2004) como Williams (2004) han propuesto estados de carácter que difieren en la clasificación de corolas infundibuliformes, siendo homólogos en lo referente a corolas hipocrateriformes o rotadas. En este análisis, las corolas infundibuliformes fueron divididas en dos estados, el primero para clasificar las corolas con la parte superior del tubo cónica y el segundo para aquellas con la parte superior campanulada. Dentro de las Echiteae, algunos pocos géneros pueden reconocerse con facilidad por la parte superior de la corola (e.g., *Angadenia*, *Pentalinon*), la cual es siempre campanulada.

26. Parte inferior del tubo

0 Recto
1 Curvado

27. Botón floral con unión lóbulo-tubo invaginada

0 Ausente
1 Presente

La presencia de coronas anulares, limitadas a unos pocos géneros en las Echiteae (Morales 1997 a, b, 2002 a; Williams 2002; Woodson 1936) provocan una invaginación en la base de los lóbulos en la zona de unión con el tubo en botones florales, que se presenta de manera constante en *Laubertia* y *Prestonia*, pero que no es perceptible en *Thoreauea* (Morales 2005 b; Williams 2002).

28. Corona anular

0 Ausente
1 Presente

29. Corona supraestaminal

0 Ausente
1 Presente

En las Echiteae, la corona epiestaminal cuando presente, está conformada por cinco apéndices más o menos foliáceos, ubicados en forma opuesta a cada antera.

30. Margen de los lóbulos en botones florales

0 Enroscados en espiral sobre su eje varias veces
1 Enroscados en espiral una sola vez

Los lóbulos de la corola en las Echiteae y Mesechiteae, se encuentran enroscados en espiral, pero de manera regular están invaginados hacia el interior, de manera que el margen externo de los lóbulos se ven enroscados en la superficie externa únicamente una sola vez. En contraposición en *Asketanthera*, los lóbulos están enroscados sobre su eje hacia el ápice del botón varias veces, de manera que el margen externo de lo lóbulos se ven enroscados varias veces sobre su eje.

31. Color predominante de los lóbulos de la corola

0 Amarillo
1 Rosado
2 Rojo o morado
3 Verde
4 Blanco o crema

32. Forma de los lóbulos

0 Filiforme
1 Ovados
2 Obovados

En forma general, la mayoría de las géneros y especies de las Mesechiteae y Echiteae tienen lóbulos oblicuamente obovados, mientras que la presencia de lóbulos ovados o filiformes es característico para unos pocos (Woodson 1936; Williams 2002; Morales & Williams 2004)

33. Lóbulos erectos o suberectos

0 Sí
1 No

Los lóbulos de la corola se encuentran usualmente extendidos de manera irregular en la mayoría de los géneros de las Echiteae y Mesechiteae. Sin embargo, lóbulos estricta-

mente erectos o suberectos, están limitados a unas pocas especies de *Mandevilla* y al género *Thoreauea* (Williams 2002; Morales 2005, b).

34. Lóbulos torcidos en espiral distalmente

0 Sí

1 No

Los lóbulos en las Apocynoideae son generalmente extendidos en la antésis, pero comúnmente reflexos de manera irregular en sus bordes; los lóbulos erectos o suberectos son menos comunes. Por otro lado, la presencia de lóbulos enroscados en espiral distalmente solo está presente en *Allotoonia* (Morales & Williams 2004).

35. Pubescencia de cara adaxial de los lóbulos

0 Ausente o inconspicua, los pelos hasta 1 mm de largo

1 Presente y conspicua, los pelos más de 2 mm de largo

Aunque la pubescencia de la corola como tal puede ser variable en las Echiteae, únicamente en *Fernaldia* se da la presencia de pelos largos y blancos en la cara adaxial de los lóbulos (Morales 2002 a).

36. Tubo de la corola

0 Diminuto, menos de 6 mm de largo

1 Pequeño, 8-19 mm de largo

2 Mediano, 20-33 mm de largo

3 Grande, más de 35 mm de largo

37. Inserción de los estambres

0 Mitad distal, cerca de la boca

1 Mitad basal, cerca de la base

38. Filamentos

0 Anteras ± sésiles

1 Menos de 1 cm de largo

2 Más de 3 cm de largo

39. Filamentos envolviendo totalmente al estilo

0 Sí

1 No

Los filamentos de la mayoría de las Echiteae y otras tribus de las Apocynoideae son muy cortos y casi ausentes, por lo que apenas tienen contacto con el estilo en la región distal de este, justo antes de la posición de la cabeza estigmática. Sin embargo, en otros géneros (e.g., *Forsteronia*, *Thenardia*, *Thoreauea*), dado el pequeño tamaño del tubo y estilo envuelven a este último casi en la totalidad de su longitud.

40. Anteras

0 Incluidas

1 Apicalmente exsertas

2 Casi totalmente exsertas

41. Pubescencia del ápice de las anteras

0 Ausente

1 Presente

La pubescencia dorsal de las anteras ha sido utilizado en otros análisis (e.g., Simões et al. 2004), pero este carácter puede variar notablemente en algunas especies. Sin embargo, pocos géneros tienen la pubescencia restringida a la región estéril y apical de las anteras, que se puede incluso prolongar en un apéndice.

42. Ápice de las anteras

0 Triangular, no prolongado en un apéndice filiforme

1 Prolongado en un apéndice filiforme

En general, la mayoría de las Apocynoideae neotropicales tienen los ápices de las anteras variadamente triangulares, ya sea agudos o acuminados. Sin embargo, la prolongación de estos apéndices por varios milímetros es raro y está limitado a unos pocos géneros.

43. Apéndices filiformes de las anteras entrelazados en espiral

0 Ausentes

1 Presentes

Los apéndices filiformes de las anteras cuando presentes, pueden ser erectos (e.g., *Tintinnabularia*) o estar entrelazados en espiral (*Pentalinon*).

44. Canales guía de las anteras

0 Compuesto principalmente de engrosamientos endoteciales

1 Compuesto principalmente de esclerénquima

45. Base de las anteras

0 Acuminadas

1 Agudas

2 Obtusas a redondeadas

46. Unión antera/cabeza estigmatica

0 Anteras unidas por un parche circular de células con apariencia de tricomas

1 Anteras unidas por un aro de pelos en forma de herradura

2 Anteras unidas por un aro de pelos en forma de herradura y una tira longitudinal delgada
3 Anteras unidas por fusión celular

47. Cabeza estigmática en corte transversal
0 Circular o subcircular
1 Pentagonal
2 Con cinco costillas prominentes

48. Costillas de la cabeza estigmática
0 Restringidas a la base
1 Distribuidas a lo largo de la cabeza estigmática

49. Anillo en la base de cabeza estigmática
0 Ausente
1 Presente

50. Nectario
0 Anular
1 Dividido en cinco glándulas

51. Gineceo
0 Apocárpico
1 Sincárpico

52. Folículos
0 Moniliformes o torulosos
1 Cilíndricos

53. Grosor de los folículos
0 Gruesos, más de 10 mm de ancho
1 Delgados, hasta 9 mm de ancho

54. Folículos con alas o costillas longitudinales
0 Sí
1 No

55. Semillas
0 Rostradas
1 Truncadas

56. Extremo micropilar de la semilla
0 Extendida más allá del punto de nacimiento de la coma
1 No extendida más allá del punto de nacimiento de la coma

La presencia de una coma micropilar en la semilla es algo común en muchas Apocynoideae. Generalmente, el extremo micropilar termina en el punto en el cual la coma nace. En muy pocas especies, el extremo micropilar se prolonga por varios mm por encima del punto de inserción de la coma, convirtiéndose en un carácter potencial para la delimitación genérica e incluso tribal.

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Book Review

Susan McClure.1996. **The Herb Gardener: A Guide for All Seasons. (Paperback edition).** (ISBN 0-88266-873-0, pbk.). Storey Publishing, 210 MASS MoCA Way, North Adams, MA, 01247. U.S.A. (**Orders:** # 66873, 1-800-441-5700; www.storey.com). $14.95, 236 pp., color photographs and drawings, appendices, index, 8 3/8" × 10".

Gardeners and cooks alike will learn a great deal from *The Herb gardener: A Guide for All Seasons.* Author Susan McClure has created a comprehensive compendium for people interested in herb gardening; subjects include a background on designing, garden duties throughout the year, crafts and projects, as well as a growing guide.

The book is divided into five main parts concerning subjects such as herbs, herb gardening Basics, seasonal planning in the garden, herb projects, and a grower's guide.

The gardening basics chapter shows the reader items to consider in planning a garden and it also aids in designing a garden space. General preplanning considerations are discussed including plant life cycles, and plant tolerances. Also included are environmental considerations before you plant (sun, soil, fertilizer, pH, water, etc.). The portion of this chapter on designing your garden will be incredibly helpful information for most readers. The author has included many different garden types/shapes such as hardscape considerations, included labeling suggestions and maintenance thoughts.

The section about yearlong gardening divides the year up into the four seasons and provides gardeners with typical, well-organized information on tasks that should occur during each period of the year. One of the very helpful features in this book are the side boxes and charts that appear throughout the text; examples are the seed sprouting facts chart in the Spring period, harvesting techniques and troubling pests and diseases charts in the summer period, first frost estimator in the fall period, and plants for an indoor garden in the winter period.

The section on recipes and crafts helps both gardeners and cooks reap the benefits of the planning and herbal harvest. This portion includes multiple methods of preserving herbs for longer-term use, good herbal combinations, recipes, herbal vinegars, cheese and butters, potpourris and wreaths. It also includes a helpful summary of nutritional value for the common herbs.

The final section of the book includes a very useful grower's guide. This section provides readers with plant profiles along with photographs of 52+ herbal plants; information is included on many varieties as well. Profiles for herbs are organized by scientific name, but also include common names, plant appearance, propagation, cultivars, potential problems, harvesting, use, and more. Each profile has summaries of information in the forms of colorful icons for quick reference.

If you have a hankering to make your own pesto or create your own herbal seasoning blend, check out *The Herb Gardener: A Guide for All Seasons* and plan your own herbal garden. McClure has written a text that is easy to read and easy to use. It's full of helpful side boxes, charts and herbal profiles. This book would be a great addition to the library of gardeners, cooks and herbal connoisseurs.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

ESTUDIOS EN LAS APOCYNACEAE NEOTROPICALES XXV: NOVEDADES Y NUEVOS REPORTES EN LAS APOCYNACEAE (APOCYNOIDEAE: RAUVOLFIOIDEAE) DE VENEZUELA

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RESUMEN

Se proponen varias novedades nomenclaturales en el género *Mandevilla*, incluyendo una nueva especie (*M. tristis* J.F. Morales), una nueva combinación (*M. angustata* (Steyermark) J.F. Morales), y un nuevo sinónimo (*M. bella* (Pittier) Woodson). Nuevas adiciones a la Flora de Venezuela en los géneros *Aspidosperma* (*A. rigidum* Rugby, *A. schultesii* Woodson), *Mandevilla* (*M. vanheurckii* (Müll. Arg.) Markgr.) y *Odontadenia* (*O. killipii* Woodson) son reportadas.

ABSTRACT

Several nomenclatural novelties are proposed in the genus *Mandevilla*, including a new species (*M. tristis* J.F. Morales), a new combination (*M. angustata* (Steyermark) J.F. Morales) and a new synonym (*M. bella* (Pittier) Woodson). New additions to the Venezuelan Flora in the genera *Aspidosperma* (*A. rigidum* Rugby, *A. schultesii* Woodson), *Mandevilla* (*M. vanheurckii* (Müll. Arg.) Markgr.), and *Odontadenia* (*O. killipii* Woodson) are reported. Several nomenclatural novelties are proposed in the genus *Mandevilla*, including a new species (*M. tristis* J.F. Morales), a new combination (*M. angustata* (Steyermark) J.F. Morales), a new report ((*M. vanheurckii* (Müll. Arg.) Markgr.) and a new synonym (*M. bella* (Pittier) Woodson).

Venezuela es uno de los países con una alta diversidad de Apocynaceae s. s., con un estimado de 30 géneros y ca. 200 especies (Morillo 1989a). El número de géneros puede variar dependiendo de la aceptación de *Tabernaemontana* como una sola unidad genérica según lo propuesto por Leeuwenberg (1994) o dividido en una serie de grupos como lo propuesto por Allorge (1985). Asimismo, la relativa confusa taxonomía prevaleciente en algunos géneros como *Aspidosperma* y la divergencia de taxones aceptados de ese género en diferentes tratamientos florísticos puede incrementar o decrecer el número estimado de taxones.

En la última monografía del género *Mandevilla*, Woodson (1933) reportó un total de 15 especies [*M. congesta* (Kunth) Woodson, *M. bella* (Pittier) Woodson, *M. caurensis* Markgr., *M. fendleri* (Müll. Arg.) Woodson, *M. hirsuta* (Rich) K. Schum., *M. javitensis* (Kunth) K. Schum., *M. lancifolia* Woodson, *M. moritziana* (Müll. Arg.) Donn. Sm., *M. scabra* (Hoffmanns. ex Roem. & Schult.) K. Schum., *M. subcarnosa* (Benth.) Woodson, *M. subsagittata* (Ruiz & Pav.) Woodson, *M. subspicata* (Vahl) Markgr., *M. surinamensis* (Pulle) Woodson, *M. veraguasensis*

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(Seem.) Hemsl., *M. villosa* (Miers) Woodson)] para Venezuela, de las cuales cuatro (*M. bella*, *M. caurensis*, *M. lancifolia*, *M. moritziana*) fueron consideradas endémicas. En forma posterior, más especies fueron descritas (e.g., Markgraf 1971, 1978; Monachino 1958, 1961; Woodson 1948) aumentando a 23 el número aproximado de taxones conocidos para el país. En su tratamiento de los géneros de Apocynaceae de Venezuela, Clausnitzer (1968) reportó un total de 22 especies, mientras que Morillo (1989 b), en conjunción con la descripción de dos nuevos taxones, reportó la presencia de *M. annularifolia* Woodson (anteriormente conocida solo de Colombia) y propuso dos nuevos sinónimos. En el tratamiento de las Apocynaceae para la Flora de la Guyana Venezolana, Morillo (1995) trato un total de 24 taxones, estimando un total de 40 especies para Venezuela. Aunque si bien este último trabajo se trata de un tratamiento de flora para un área geográfica específica (y no para toda Venezuela), tiene una relativa importancia, por el hecho de incluir algunas especies previamente no conocidas en el país. El tratamiento preliminar de una nueva monografía de *Mandevilla* (Morales, datos sin publ.) contabiliza un total de al menos 37 taxones en Venezuela, algunos recientemente descritos (Morales 2005). De ellos, tan solo cinco pertenecen al subgénero *Mandevilla*, mientras que el resto pertenecen al subgénero *Exothostemon* (Woodson 1933). Como resultado, varias novedades son propuestas, incluyendo nueva sinonimia, un nuevo reporte, una nueva combinación, y una nueva especie.

Por otro lado, hasta el momento, no existe un tratamiento completo de la familia (s.s.) para el país y únicamente tratamientos para los géneros (Clausnitzer 1968) o regiones geográficas determinadas (e.g., Morillo 1989a; Zarucchi et al. 1995) han sido publicados.

Mientras revisaba material sin identificar de Venezuela, varios taxones previamente no reportados para ese país de los géneros *Aspidosperma* (Rauvolfioideae) y *Odontadenia* (Apocynoideae) fueron identificados, así como una serie de novedades taxonómicas en *Mandevilla* (Apocynoideae) estas últimas derivadas principalmente de la elaboración de una nueva monografía para el género. Estas novedades son presentados a continuación, agrupados en subfamilias y tribus de acuerdo a la clasificación propuesta por Endress y Bruyns (2000).

Mandevilla angustata (Steyerm.) J.F. Morales, comb. & stat. nov. (**Fig. 1**). BASIÓNIMO: *Mandevilla subcarnosa* var. *angustata* Steyerm., Acta Bot. Venez. 2:318. 1967. TIPO: VENEZUELA. BOLIVAR: Auyan-tepuí, cumbre de la parte Norte, entre campamento Llovizna y pie del segundo Muro, 11 May 1965 (fl), *Steyermark 93737* (HOLOTIPO: VEN; ISOTIPOS: MO (fotocopia en INB), US, VEN).

Lianas o arbustos erectos; ramitas jóvenes levemente anguladas o aladas, subteretes con la edad, tallos sólidos a ligeramente huecos, glabros; coléteres interpeciolares inconspicuos, hasta 0,8 mm de largo. Hojas opuestas; pecíolos

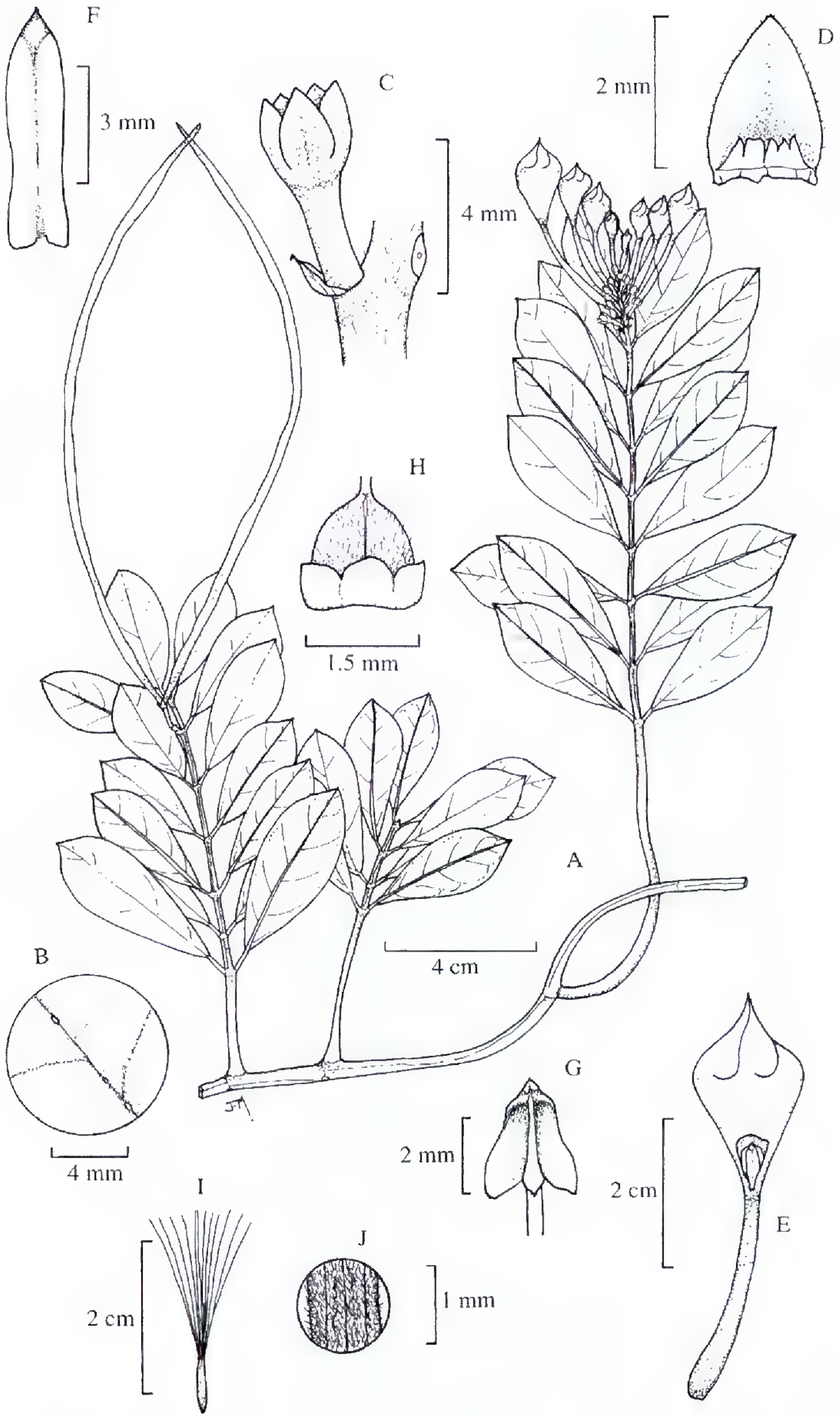


Fig. 1. *Mandevilla angustata* (*Liesner & Holst 20762*, VEN). **A.** Ramita fértil con flores y frutos. **B.** Detalle de la superficie adaxial de la hoja, mostrando los coléteres a lo largo del nervio central. **C.** Cáliz, pedicelo y bráctea. **D.** Vista adaxial de un sépalo, mostrando el coléter irregularmente lacerado. **E.** Tubo de un botón parcialmente abierto, mostrando la posición de las anteras y el tubo basalmente giboso. **F.** Antera, vista dorsal. **G.** Cabeza estigmática. **H.** Nectario y ovario. **I.** Semilla. **J.** Detalle de la pubescencia de las semilla.

3–8 mm de largo; láminas foliares 2,6–10 × (1–)1,4–3,9(–5) cm, obovadas a obovado–elípticas, el ápice obtuso, obtuso–apiculado a agudo, la base cuneada, los coléteres distribuidos en forma irregular a lo largo del nervio central, firmemente membranáceas, glabras o glabrescentes, usualmente no revolutas, venas secundarias y terciarias apenas impresas en ambas superficies. Inflorescencia ligeramente más larga que las hojas subyacentes, subterminal, pero rápidamente volviéndose axilar, diminuta e inconspicuamente puberulenta cuando jóven, pero volviéndose rápidamente glabra o glabrescente, con 5 a 15 flores, sésiles o subsésiles, el pedúnculo (cuando raramente presente) de 1–5 mm de largo, pedicelos 3–5 mm de largo (a veces hasta 8 mm en fructificación), brácteas 1–2 × 0,5–1 mm, angostamente ovadas, escariosas; sépalos 2–3 × 1,4–1,7 mm, ovados, obtusos a agudos apicalmente, el ápice no reflexo, escariosos, glabrescentes externamente, diminuta e inconspicuamente ciliolados marginalmente, el coleter solitario, irregularmente lacerado apicalmente; corola infundibuliforme, amarilla, inconspicuamente papilada a glabrescente externamente, el tubo giboso basalmente, la parte inferior 27–32 × 2–2,5 mm, la parte superior 13–19 mm de largo, cónica, 14–22(–25) mm de diámetro en la fauce, el ápice del botón floral agudo o cortamente apiculado; lóbulos 16–18(–21) × 9–13(–17) mm, obovados, relativamente extendidos, ligera e irregularmente reflexos marginalmente; estambres insertos en la base de la parte superior del tubo, anteras 6–7,4 mm de largo, glabras dorsalmente, la base auriculada, con las aurículas subtruncadas, cabeza estigmática 2,7–3 mm de largo; ovario 1,3–1,7 mm de largo, diminuta y moderadamente puberulento; nectario anular, leve a moderadamente pentalobulado, ca. la mitad (o ligeramente menos) de la longitud total del ovario. Folículos 15,5–18 cm × 1,5–3,5 mm, glabros, levemente moniliformes; semillas 7–7,5 mm de largo, diminuta y densamente hirsutulas, coma 1,4–2,1 cm de largo, canela–amarillo.

Distribución, hábitat y ecología.—Restringida al E de Venezuela (estado de Bolivar) y Guyana (región Potaro-Siparuni), donde crece en bosques enanos y ventosos, en elevaciones de (450–)950–2000 m. Especímenes con flores han sido recolectados en Mayo y Octubre. Especímenes con frutos fueron recolectados en Mayo.

En su descripción de *M. subcarnosa* Benth. var *angustata*, Steyermark (1967) mencionó que esta diferia de la variedad típica (la que ocurre en el S y SE de Venezuela, Guyana y el N de Brasil en el Estado de Roraima) por sus hojas con las bases "angostadas y cuneado–agudas" (vs. redondeadas u obtusas a subcordadas), así como láminas foliares oblanceoladas u oblanceolado–oblongas (vs. oblongas). En forma general estos caracteres son persistentes, pero existen suficientes caracteres adicionales que justifican el elevar su estatus a nivel específico. De esta manera, *M. angustata* se puede diferenciar de *M. subcarnosa* por sus hojas con las venas secundarias conspicuamente arcuadas (vs. dispuestas

perpendicularmente), separadas por 4–10 mm entre sí (vs. 2–5 mm), así como inflorescencias sésiles o subsésiles, con el pedúnculo de 1–3 mm de largo (vs. pedunculadas y con el pedúnculo de 12–45 mm), folículos de 16–18 cm de largo (vs. 7–13,5 cm) y semillas diminuta y densamente hirsutulas, con el indumento erecto a suberecto (vs. densamente tomentulosas y con el indumento adpreso).

Especímenes examinados. **VENEZUELA. Bolivar:** Piar, cima del Amaruay-tepuí, 10 May 1986 (fl), *Liesner & Holst 20762* (MO, VEN); Ptarí-tepuí, cercanías del campamenteo Misia Kathy, 28 Oct 1944 (fl), *Steyermark 59473* (MO). **GUYANA:** Montañas Pakaraima, Aymatoi, 17 Oct 1981 (fl), *Maas et al. 5801* (K, MO, U), *Maas et al. 5824* (U, WAG); región Potaro-Siparuni, río Blackwater, 22 May 1991 (fl), *McDowell et al. 4895* (US, WAG).

Mandevilla boliviensis (Hook. f.) Woodson, Ann. Missouri Bot. Gard. 20:716. 1933.

Dipladenia boliviensis Hook. f., Bot. Mag. 95:t. 5783. 1869. TIPO: BOLIVIA: Datos perdidos (fl), *Pearce 708* (HOLOTIPO: K, foto, MO).

Mandevilla bella (Pittier) Woodson, Ann. Missouri Bot. Gard. 20:717. 1933, syn. nov. *Dipladenia bella* Pittier, J. Wash. Acad. Sci. 21:141. 1931. TIPO: VENEZUELA. DISTRITO FEDERAL: Hacienda Puerto La Cruz, región costera, 2300 m, 28 Ago–4 Sep 1918 (fl), *Pittier 8108* (HOLOTIPO: US).

La única diferencia mencionada por Woodson (1933) para separar *Mandevilla bella* de *M. boliviensis* (Hook. F.) Woodson fue la longitud y forma del ápice de los lóbulos de la corola, así como distribución geográfica disyunta. Sin embargo, no existen diferencias adicionales en otros caracteres morfológicos en los especímenes tipo que permitan reconocer ambos taxones. En todo caso, la longitud de los lóbulos es muy variable en el material de *M. boliviensis* disponible hoy en día, lo que en conjunción con la alta variación en la longitud y tamaño de la corola presente en otras especies del subgénero *Mandevilla* (e.g., *M. pohliana* (Stadelm.) A. Gentry), impide reconocer ambos taxones. Otros sinónimos de *M. boliviensis* fueron anteriormente propuestos por Morales (1995, 1998).

Mandevilla tristis J.F. Morales, sp. nov. (**Fig. 2**). TIPO: VENEZUELA. TÁCHIRA: Uribante, S base de Cerro El Morro, 21 Jun 1990 (fl, fr), *Dorr et al. 7115* (HOLOTIPO: NY; foto, INB).

A *Mandevilla bracteata* (Kunth) Kuntze, *M. hirsuta* (Rich) K., Schum. *M. sagittarii* Woodson et *M. steyermarkii* Woodson, cui similis, foliis sessilis vel subsessilis, petiolis 1–2 mm longis, et bracteis 1,2–2 mm latis differt.

Liana; ramitas algo aplanadas cuando jóvenes, teretes a subteretes con la edad, ligeramente huecas, densamente tomentulosas cuando jóvenes, esparcida a moderadamente puberulentas con la edad, más raramente glabrescentes; coléteres interpeciolares inconspicuos, hasta 0,9 mm de largo. Hojas opuestas; pecíolos 1–2 mm de largo; láminas foliares 2–7,3 × 1,5–3,2(–3,7) cm, ovadas a ovado-elípticas, el ápice cortamente cuspidado, la base cordada, los coléteres irregularmente distribuidos a lo largo del nervio central, membranáceas, diminuta y esparcidamente papilado-puberulentas en la superficie adaxial, la pubescencia más densa sobre el nervio central, diminuta y densamente

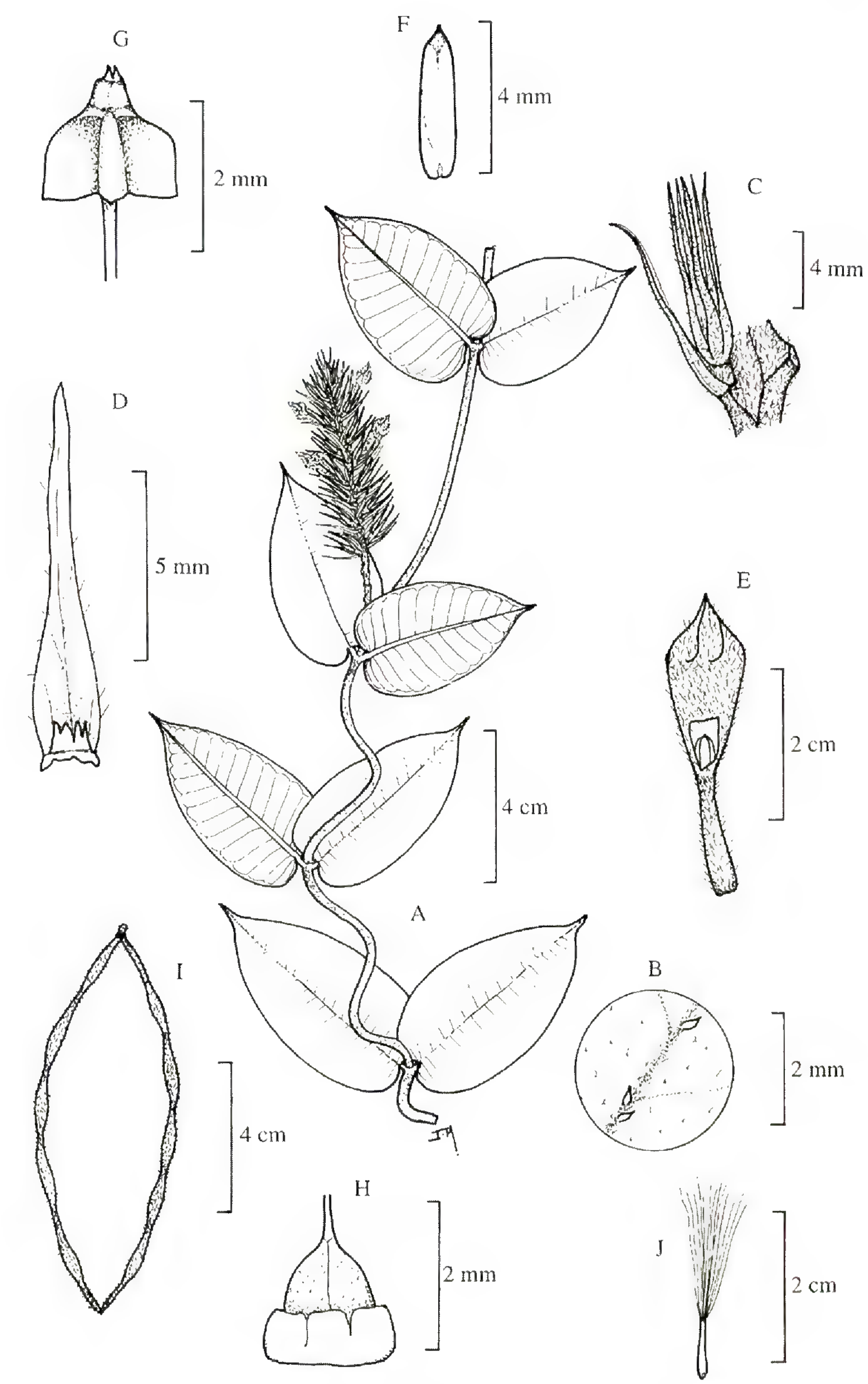


FIG. 2. *Mandevilla tristis* (A–H de *Werff & González 5313*, INB; I–J de *Dorr et al. 7115*, NY). **A.** Ramita con inflorescencia. **B.** Detalle de la superficie adaxial de la hoja, mostrando los coléteres a lo largo del nervio central. **C.** Cáliz, pedicelo y bráctea. **D.** Vista de la cara adaxial de un sépalo, mostrando el coléter. **E.** Tubo de un botón parcialmente abierto, mostrando la posición de las anteras y el tubo basalmente giboso. **F.** Antera, vista dorsal. **G.** Cabeza estigmática. **H.** Nectario y ovario. **I.** Folículos. **J.** Semilla.

tomentosas en la superficie abaxial, el indumento secando glauco, no revolutas, venas secundarias y terciarias conspicuamente impresas en la superficie abaxial, usualmente solo las venas secundarias apenas visibles en la superficie adaxial. Inflorescencia usualmente más larga que las hojas subyacentes, axilar, densa a moderadamente puberulentas, con muchas flores, pedúnculo 4–16(–20) mm de largo, pedicelos 1–1,5 mm de largo, raramente algunos pocos alcanzando los 3 mm de largo en fructificación, brácteas 9–15 × 1,2–2 mm, linear-ovadas, subfoliáceas; sépalos 8,5–11 × 0,5–1 mm, linear-ovados, largamente acuminados apicalmente, el ápice no reflexo, escariosos, densa a moderadamente puberulentos externamente, el coleter solitario, irregularmente laciniado apicalmente; corola infundibuliforme, amarilla, algo giboso, densamente a moderadamente hispídulosa externamente, sobretodo en botones florales, el tubo giboso basalmente, la parte inferior 13–18 × 2–3,6 mm, la parte superior 14–16 mm de largo, cónica, 10–13 mm de diámetro en la fauce, el ápice del botón floral cortamente apiculado; lóbulos 8–12 × 7–11 mm, obovados, relativamente extendidos; estambres insertos en la base de la parte superior del tubo, anteras 3,6–4,1 mm de largo, glabras dorsalmente, la base auriculada, con las aurículas redondeadas, cabeza estigmática 1,6–1,9 mm de largo; ovario 1,3–1,5 mm de largo, inconspicua y diminutamente papilado-puberulento a glabrescente; nectario anular, moderada a profundamente pentalobulado, ca. la mitad de la longitud total del ovario. Folículos 10,5–13,5 cm × 1–3,6 mm, densa a esparcidamente hispídulos, conspicuamente moniliformes; semillas 7,5–8 mm de largo, glabras a glabrescentes, coma 1,7–2,4 cm de largo, canela.

Distribución, hábitat y ecología.—Endémica al estado del Táchira en el E de Venezuela, donde crece en formaciones de sabanas y vegetación arbustiva asociada a afloramientos rocosos o arenosos, en elevaciones de 1100–1300 m. Especímenes con flores y frutos han sido recolectados en Junio, pero material con flores se conoce también de Julio.

Especímenes examinados. **VENEZUELA. Táchira:** Uribante, entre Siberia y Pregonero, 11 Jul 1983 (fl), *Werff & González 5313* (INB, MO).

Mandevilla tristis se puede confundir con *M. bracteata* (Kunth) Kuntze, *M. hirsuta* (Rich) K. Schum., *M. sagittarii* Woodson y *M. steyermarkii* Woodson, un grupo de taxones que se caracterizan por sus inflorescencias con brácteas foliáceas o subfoliáceas y corolas infundibuliformes. Sin embargo, *M. tristis* puede distinguirse fácilmente por sus hojas subsésiles (pero aparentando ser sésiles), con los pecíolos inferiores a 2 mm de largo (vs. 4–60 mm de largo), inflorescencias con las brácteas florales mucho más angostas (1,2–2 mm vs. 3–9 mm), flores subsésiles, con el pedicelo hasta 1,5 mm de longitud (vs. 2–8 mm de largo) y corolas con el tubo más pequeño y con un diámetro más angosto en la fauce.

SUBFAMILIA APOCYNOIDEAE

Tribu Apocyneae

Odontadenia killipii Woodson, Ann. Missouri Bot. Gard. 18:546–547. 1931. TIPO: PERÚ. LORETO: Iquitos, 26 Sep 1929 (fl), *Killip & Smith 29847* (HOLOTIPO: MO; ISOTIPO: US).

Odontadenia killipii es un taxón relativamente fácil de reconocer por el tamaño relativamente pequeño de sus sépalos, corolas y folículos. Aunque ha sido confundida con la común *O. verrucosa* (Willd. ex Roem. & Schult.) K. Schum. ex Markgr., *O. killipii* puede reconocerse por sus sépalos relativamente más pequeños (2–4 mm vs. 3–9 mm), corolas glabras externamente (vs. esparcidamente puberulentas a glabrescentes), con la parte superior del tubo de la corola anchamente cónica (vs. angostamente cónica) y folículos mucho más pequeños (7,5–10,5 cm vs. (13–)19–30 cm) (Morales 1999). *Odontadenia killipii* era conocida del S de Colombia a través de Ecuador hasta Perú, la Guyana Francesa y Brasil, pero se reporta por primera vez para Venezuela, es el estado de Amazonas.

Especímenes examinados. **VENEZUELA. Territorio Federal Amazonas:** Río Negro, Serranía de Tapirapeco, May 1992 (fl), *Martin 1909* (MO, PORT); Atabapo, Oct 1989 (fl), *Velasco 730* (MO).

Tribu Mesechiteae

Mandevilla vanheurckii (Müll. Arg.) Markgr., Notizbl. Bot. Gart. Berlin-Dahlem 9:87, fig. 2L. 1924. *Heterothrix vanheurckii* Müll. Arg., Observ. Bot. 164. 1871. *Eriadenia obovata* Miers, Apocyn. S. Amer. 117–118, t. 14 B. 1878, nom. superfl. TIPO: PERÚ. LORETO: cerca de Tarapoto, fecha perdida (fl), *Spruce 4303* (HOLOTIPO: W, foto F neg. 31792; ISOTIPOS: BM, CGE, F (fragmento), G, foto F neg. 26855, K [2 láminas], P).

Este taxón fue originalmente reportado por Clausnitzer (1968) para Venezuela (pero sin testigo citado). Posteriormente, Morillo (1995) trato este taxón como "*Mandevilla* sp. A." en el tratamiento de la Flora de la Guayana Venezolana, aunque hizo referencia que esta especie había sido conocida como *M. vanheurckii*. El estudio del tipo, así como de diversos especímenes no deja duda de que este taxón está presente en Venezuela, donde se conoce de los Estados de Amazonas y Bolivar. En forma general, esta especie se puede confundir con *M. subcarnosa* (Benth.) Woodson, ya que ambas comparten varios caracteres tales como tallos algo angulados cuando jóvenes, hojas con el indumento ausente o glabrescentes y no evidente, inflorescencias con brácteas escariosas, con pedicelos cortos y corolas infundibuliformes, pero *M. vanheurckii* se distingue por facilidad por sus láminas foliares con las venas secundarias y terciarias usualmente no evidentes.

Especímenes examinados. **VENEZUELA. Amazonas:** Casiquiare, alrededores de Yavita, río Temi, 6-19 Jul 1969 (fl, fr), *Bunting et al. 3736* (U); Río Negro, SE de San Carlos de río Negro, 12 Nov 1987 (fl), *Liesner & Carnevali 23012* (MO, WIS); cerro de la Neblina, río Yatua, 14 Nov 1957 (fl, fr), *Maguire et al. 42069* (F, NY, US); cerro de la Neblina, río Yatua, 1 Ene 1958 (fl), *Maguire et al. 42570* (K, NY, U, VEN); carretera San Carlos–Solano, 3 Feb 1977 (fl), *Morillo 5153* (VEN); Atures, caño Piedra, SE de

Puerto Ayacucho, Sep 1989 (fl, fr), *Sanoja et al. 2965* (MO, NY, PORT). **Bolivar:** Uaipán-tepuí, Feb 1948 (fl), *Phelps et al. 384* (NY); Sororopán-tepuí, 14 Nov 1944 (fl), *Steyermark 60149* (F).

SUBFAMILIA RAUVOLFIOIDEAE

Tribu Alstonieae

El género *Aspidosperma* (Rauvolfioideae, Alstonieae) se encuentra ampliamente distribuido desde el S de México hasta Bolivia, Paraguay y el N de Argentina, así como en las Antillas, donde está representado por pocas especies. En forma general, es uno de los grupos de las Apocynaceae neotropicales con una de las más altas variaciones intraespecíficas, en cuanto a la forma de las hojas e indumento de partes vegetativas e inflorescencias. Debido a esto, un sin número de formas, variedades y taxones han sido propuestos para albergar diferentes estados dentro del rango de variación de una misma especie, provocando una divergencia notable en cuanto al número de taxones aceptados en el género. De esta manera, Woodson (1951), reconoció un total de 52 especies, mientras que la revisión de Marcondes-Ferreira (datos sin publ.) aceptó un total de 34 taxones. Clausnitzer (1968) reportó un total de 16 taxones para Venezuela, mientras que Morillo (1995), estimo que ca. 30 especies estaban presentes en el país. Ahora bien, en el transcurso de identificación de material sin identificar depositado en el Missouri Botanical Garden (MO), dos taxones anteriormente no conocidos en Venezuela, pertenecientes al subgénero *Aspidosperma* (Marcondes-Ferreira & Kinoshita 1996) fueron encontrados, ambos restringidos a la cuenca baja amazónica.

Aspidosperma rigidum Rusby, Mem. New York Bot. Gard. 7:323. 1927. TIPO: BOLIVIA. LA PAZ: río Bopi, 12 Sep 1921 (fl), Rusby 593 (HOLOTIPO: NY).

Aspidosperma jaunechense A. Gentry, Phytologia 47:98–99. 1980, syn. nov. TIPO: ECUADOR. LOS RÍOS: Vinces, bosque de Jauneche, 26 Mar 1980 (fl), *Dodson & Gentry 9920* (HOLOTIPO: MO; ISOTIPO: SEL).

Aspidosperma rigidum pertenece a la sección *Rigida* (Marcondes-Ferreira & Kinoshita 1996) y ahora se encuentra distribuida en Costa Rica, Colombia, Venezuela, Ecuador, Perú, Bolivia y el NO de Brasil. En general, esta especie se puede reconocer con facilidad por la siguiente combinación de caracteres: fuste principal conspicua e irregularmente acanalado, tallos jóvenes con las yemas apicales sin catafilos, hojas de 4–11 cm de largo, elípticas y membranáceas, inflorescencias laterales, con los lóbulos de la corola angostamente elípticos y folículos hasta 7 cm de largo, dolabriformes, lisos externamente y con las semillas secando negras. De forma vegetativa, se puede confundir con facilidad con las especies de la sección *Excelsa* (Marcondes-Ferreira & Kinoshita 1996), pero *A. rigidum* se puede reconocer por sus láminas ovado-acuminadas y venas secundarias arquedas y unidas a la siguiente en forma terminal, formando una vena terminal.

En la descripción de *Aspidosperma jaunachense*, Gentry (1980) únicamente

clasificó ese taxón dentro de la clasificación intragenérica propuesta por Woodson (1951), pero sin discutir en forma directa sus relaciones con alguna especie en particular. Sin embargo, aunque él citó que este taxón era muy similar a *A. rigidum*, no profundizó en discutir las diferencias que podrían separar ambos taxones. De hecho, el estudio de los tipos ha revelado que no existen diferencias significativas que justifiquen la validez de *A. jaunachense* por lo que es reducido a la sinonimia.

Especímenes examinados. **VENEZUELA. Territorio Federal Amazonas:** misión río Mavaca, 11 Feb 1991 (fl, fr), *Stergios et al. 15335* (INB, MO, PORT).

Aspidosperma schultesii Woodson, Ann. Missouri Bot. Gard. 38:168, t.1, f.6. 1951.

TIPO: BRASIL: Amazonas entre cabeceras de Ira-Igarapé y cabeceras de Igarapé Abiú, afluente del río Taraíra, 4–6 Jul 1948 (fl), *Schultes & López 10178* (HOLOTIPO: MO; ISOTIPO: F).

Aspidosperma schultesii, pertenece a la sección *Schultesia* (Marcondes-Ferreira & Kinoshita 1996), y dentro del género es un taxón bastante distintivo que se puede reconocer con facilidad por sus ramitas jóvenes sin catafilos, tallos y pecíolos secando negros, glabrescentes, láminas foliares con la venación secundaria apenas evidente o no evidente, así como corolas con los lóbulos ca. 3 veces más largos que el tubo, y folículos negros al secar, con la superficie externa conspicuamente granulada. Esta especie se encuentra ahora distribuida en Colombia, Venezuela, N de Brasil y Perú.

Especímenes examinados. **VENEZUELA. Territorio Federal Amazonas:** San Carlos de Río Negro, al de la confluencia del Río Negro y el brazo Casiquiare, 29 Feb 1980 (fr), *Clark & Maquirino 7367* (MO).

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Book Review

David Stuart. 2004. **Dangerous Gardens: The quest for plants to change our lives.** (ISBN 0-674-01104-X, hbk.). Harvard Press, Cambridge, MA (**Orders:** TriLiteral LLc, 100 Maple Ridge Dr., Cumberland, RI 02864-1769, U.S.A., 800-405-1619 http://www.hup.harvard.edu/). $35.00, 208 pp., color drawings, color and b&w photo, bibliography, and index, 7 1/2" × 10 3/8".

Do poisonous plants and aphrodisiacs interest you? What about medicinal plants, life elixirs, and "mind expanding" plants? Then you should venture into the enjoyable new book called *Dangerous Gardens: The quest for plants to change our lives.*

Author David Stuart has created this intriguing text about mankind's use of plants to pursue health, happiness and long life. The book is divided into chapters that focus on different subject areas to which plants have been applied by humankind: "Great Afflictions," " The Vital Organs," "The Flight from Pain," "Chasing Venus," "The Killing Plants," "The Seven Ages of Man," "The Mind" and "Mysteries of the Gods." The author provides both historical background and historical reasoning regarding why plants were used for different illnesses or desires. For example, the book begins with a history of the plague and the various attempts to use plants as a cure. Other examples appear throughout the book regarding how plants were often being used for one reason and accidentally or eventually learned that the same plant actually cured other illnesses. Foxglove (*Digitalis purpurea*), for example, in the 1600/1700s was used for wounds and lung ailments; not until the late 1700s was it learned that this same plant had dramatic effects on the heart. The text also describes many plants that were liberally used in history until their true and often-dangerous behavior was unearthed. One example is opium, which up until the late 1800s was used liberally as a cure for all kinds of ailments. The book contains many other interesting subject matter including the histories of famous poisoners, "cure-all" quack pills, plant use in rituals and the use of various plants as aphrodisiacs. The author also included information in various chapters on what he has labelled "shadow plants;" plants that are often used for treatment, such as purple coneflower (*Echinacea* spp.), but that science and/or the medical community has not determined the true benefit and risks, if any.

I found *Dangerous Gardens* hard to put down, it reads like a very good cable TV documentary on plant use by man, complete with photographs and/or drawings of the plants being discussed, practitioners of herbal medicine, perpetrators of poisoning, quackery, and many other historical images related to plant use. This book was insightful regarding the rationale that was used to decide which plants to use for different illnesses. It was fascinating to learn about how various plants were used differently throughout time. This book is recommended to anyone with an interest in the topic of plant use by mankind; it is easy to read and engaging.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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TAXONOMIC OVERVIEW OF THE *HETEROTHECA VILLOSA* COMPLEX (ASTERACEAE: ASTEREAE)

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ABSTRACT

Heterotheca villosa (as treated by Semple 1996, 2006) is a complex species with nine varieties, most of which are sympatric in various degrees. *Heterotheca villosa* var. *nana* and *H. villosa* var. *scabra* are essentially allopatric and intergrade little, but each is widely sympatric with *H. villosa* and distinct from it. Recognition at specific rank accurately reflects the status of var. *nana* and var. *scabra*, and they are treated here, respectively, as *Heterotheca horrida* (Rydb.) Harms and *Heterotheca polothrix* Nesom, nom. et stat. nov. *Heterotheca stenophylla* sensu stricto is distinct from *H. stenophylla* var. *angustifolia* (sensu Semple) and sympatric with it, and the latter is appropriately treated as *H. villosa* var. *angustifolia* (Rydb.) Harms. The New Mexico endemic *Heterotheca villosa* var. *sierrablancensis* Semple is raised to specific rank as *Heterotheca sierrablancensis* (Semple) Nesom, comb. et stat. nov. Identifications of vars. *villosa*, *foliosa*, *ballardii*, and *minor* (all sensu Semple) require arbitrary judgements because of their broad sympatry and extensive intergradation. The distinction between var. *pedunculata* and *H. zionensis* is not clear, and both taxa apparently intergrade broadly with more typical *H. villosa*. Variety *depressa* is maintained at specific rank as *H. depressa* (Rydb.) Dorn. Maps show the generalized distributions of the taxa of the *H. villosa* complex sensu Semple, and a nomenclatural summary outlines an alternative taxonomy.

RESUMEN

Heterotheca villosa (as treated by Semple 1996, 2006) es un complejo de especies con ocho variedades, la mayoría de las cuales son simpátricas en varios grados. *Heterotheca villosa* var. *nana* y *H. villosa* var. *scabra* son esencialmente alopátricas y se intergradan poco, pero cada una de ellas es ampliamente simpátrica con *H. villosa* y diferente de ella. El reconocimiento a nivel específico refleja con precisión el estatus de var. *nana* y var. *scabra*, y son tratadas aquí, respectivamente, como *Heterotheca horrida* (Rydb.) Harms y *Heterotheca polothrix* Nesom, nom. et stat. nov. *Heterotheca stenophylla* sensu stricto es diferente de *H. stenophylla* var. *angustifolia* (sensu Semple) y simpátrica con ella, y esta última es tratada apropiadamente como *H. villosa* var. *angustifolia* (Rydb.) Harms. La endémica de Nuevo México *Heterotheca villosa* var. *sierrablancensis* Semple se eleva al rango específico como *Heterotheca sierrablancensis* (Semple) Nesom, comb. et stat. nov. Las identificaciones de las vars. *villosa*, *foliosa*, *ballardii*, y *minor* (todas sensu Semple) requieren juicios arbitrarios debido a su amplia simpatria e intergradación extensa. La diferenciación entre var. *pedunculata* y *H. zionensis* no es clara, y ambos taxa aparentemente se intergradan con la más típica *H. villosa*. La variedad *depressa* se mantiene en el rango específico como *H. depressa* (Rydb.) Dorn. En los mapas se muestran las distribuciones generales de los taxa del complejo *H. villosa* sensu Semple, y un resumen nomenclatural delinea una taxonomía alternativa.

Intermediates between taxa of *Heterotheca* are often encountered and unequivocal identifications are correspondingly difficult. Phenotypic plasticity, small

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degrees of differentiation, and hybridization apparently underlie the taxonomic difficulties. Tetraploids are common and gene exchange among them apparently occurs frequently. A monograph of *Heterotheca* sect. *Phyllotheca* (Semple 1996) provides a detailed view of the taxonomic structure of this group and addresses difficulties in identification.

Heterotheca villosa, as treated by Semple (1996, 2006), is a widespread and complex species with nine varietal taxa, most of which are geographically overlapping or almost completely superimposed. Typical *H. villosa* (var. *villosa*) occupies essentially the northern half of the species range, but it is broadly sympatric with var. *minor*, var. *foliosa*, var. *ballardii*, and var. *nana*. In part of Nebraska and South Dakota, five varieties (sensu Semple) of *H. villosa* occur sympatrically; four varieties occur sympatrically in Saskatchewan; three occur sympatrically in much of Wyoming, Colorado, and Utah. Two are relatively narrow endemics (within a single state); all the others occur in at least four states. All taxa were mapped in detail by Semple (1996, Figs. 39 and 40); generalized outline maps shown here (Figs. 1, 2, 3) are derived in most part from Semple's dot maps.

Regarding the *Heterotheca villosa* complex, Semple (1996, p. 114) noted that it might be "logical to merge all ... varieties together with no infraspecific taxa being recognized ... This would result in the loss from the formal nomenclature of a great deal of information on variation and distribution in what is admittedly a difficult species complex." His approach (as noted by Nesom 1997) has been to recognize sympatric conspecific varieties, using formal varietal names to identify what many (or most) systematists might regard as geographical trends or populational variants. "A variety is characterized by all members of a population exhibiting a particular morphology distinct from other individuals in the species. The distribution of these populations is sympatric with populations whose members are not within the same variety, and also many populations of morphological intermediates exist [citing various references]. ... Van Steenis described varietal level variation as being continuous with other varieties, although the continuum would have pronounced modes" (Semple 1974, p. 8–9). Similarly, and with regard to *Heterotheca villosa*, "the races fit well with the concept of variety in that each occurs in pure form in some populations, and the overall ranges are sympatric to a considerable degree with at least one other variety" (Semple 1996, p. 108).

Semple has used a similar taxonomic approach for *Heterotheca sessiliflora* (Nutt.) Shinners sensu lato, a primarily Californian complex, and formal changes in taxonomic rank were proposed by Nesom (1997) to clarify its systematics. The taxonomic situation with *H. villosa* (Pursh) Shinners is considered here. Harms (1968, 1970) also has addressed aspects of the taxonomy of the *H. villosa* complex.

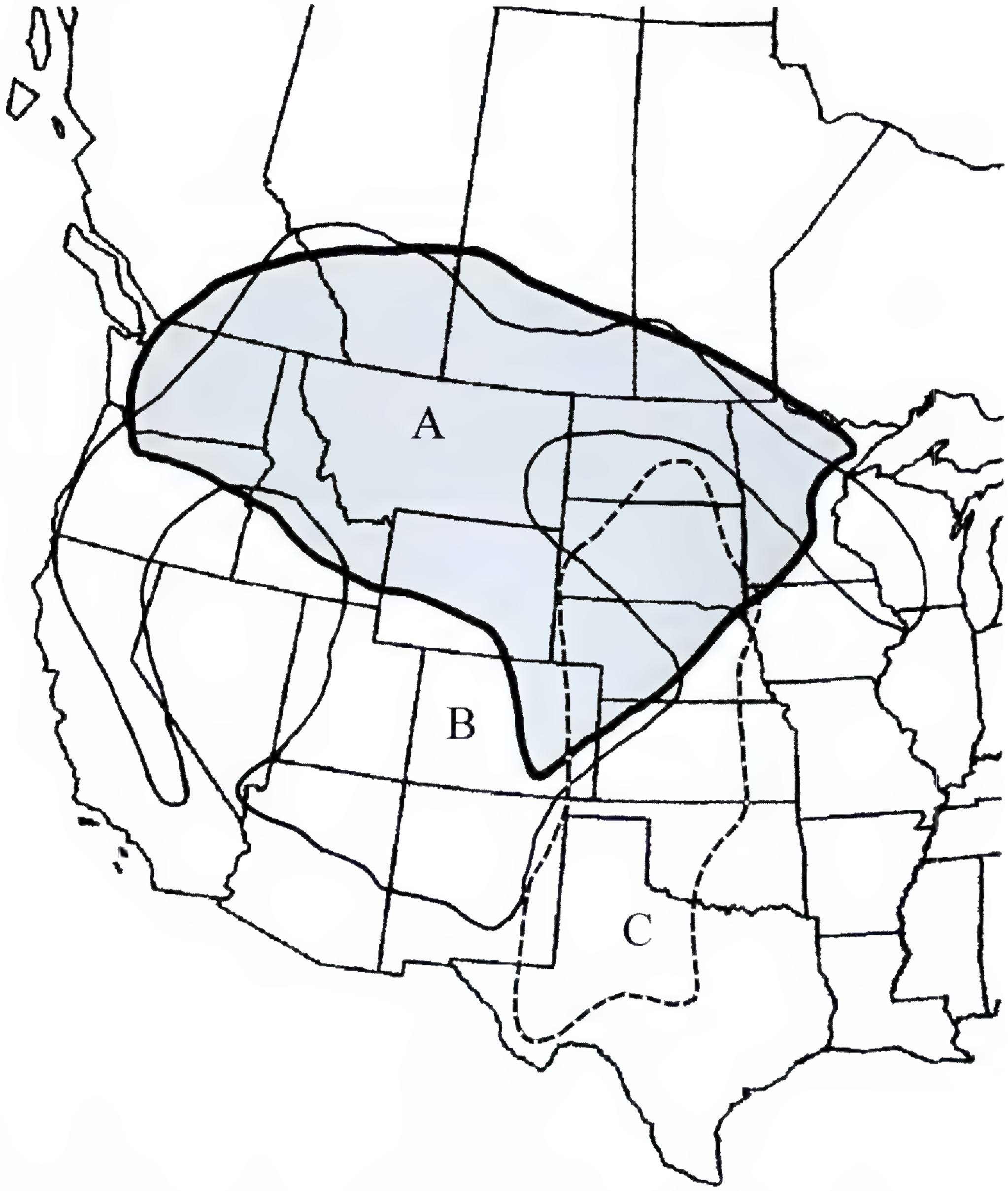


FIG. 1. Generalized distribution of *Heterotheca villosa* (**A**) var. *villosa* and (**B**) var. *minor*, both sensu Semple, and (**C**) *H. villosa* var. *angustifolia*. Illustrated is the broad sympatry of var. *villosa* and var. *minor* and the partial sympatry/allopatry of var. *angustifolia*. The range of *H. villosa*, mapped here as var. *minor*, includes southern Nevada (Clark Co., Excelsior Canyon, 7 Sep 1941, *Clokey 8759*-MO). The range of var. *angustifolia* includes northwestern Iowa (Lyon Co., prairie, among Sioux Quartzite exposures, nw corner of county, 25 Aug 1924, *Shimek s.n.*-MO).



FIG. 2. Generalized distribution of *Heterotheca villosa* (**A**) var. *foliosa*, (**B**) var. *ballardii*, (**C**) *H. zionensis*, and (**D**) var. *pedunculata*, all sensu Semple. Compare with Fig. 1 to see broad sympatry of var. *foliosa* and var. *ballardii* with var. *villosa* and var. *minor*.

Status of *Heterotheca villosa* var. *pedunculata*

Heterotheca villosa **var. *pedunculata*** occurs in complete sympatry with *H. villosa* var. ***minor*** in the Four Corners region, as indicated by Semple (1996) (var. *pedunculata* with upper cauline leaves densely to extremely densely strigose, thus pale green to white, eglandular to very sparsely glandular; $2n = 18, 36$; var. *minor* with upper cauline leaves sparsely to moderately densely strigose, sparsely to densely glandular; $2n = 18, 36$). Variety *minor* "is the most variable [infraspecific taxon] in the species and includes some local distinctive morphotypes that grade into other forms. Plants intermediate between this and all other varieties occur in areas where the ranges are sympatric, and they make infraspecific taxonomy of the species difficult" (Semple 2006). In a study of

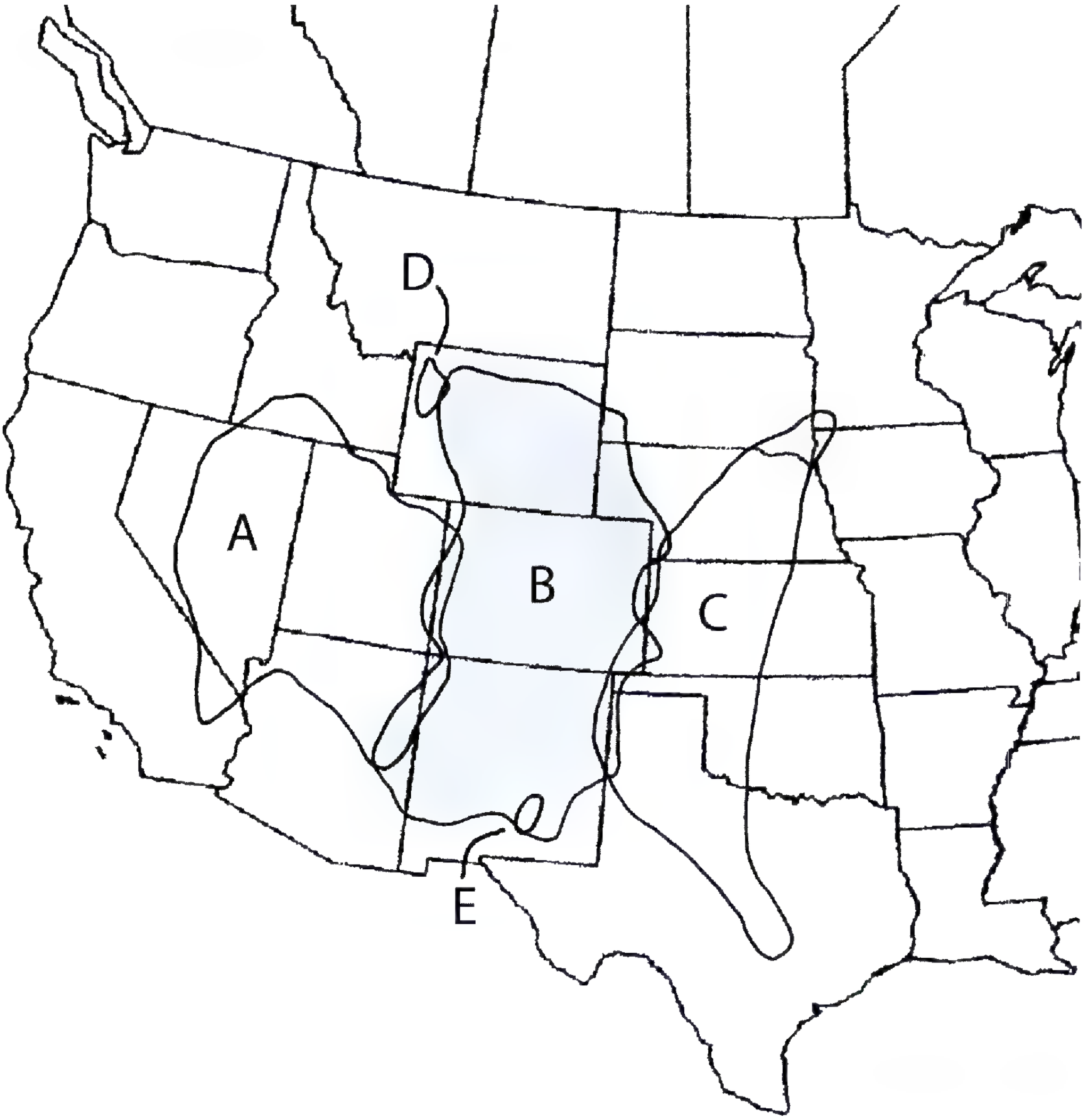


FIG. 3. Generalized distribution of **(A)** *Heterotheca polothrix*, **(B)** *H. horrida*, **(C)** *H. stenophylla*, **(D)** *H. depressa*, and **(E)** *H. sierrablancensis*. Illustrated are the distributions of taxa recognized here at specific rank.

Four Corners *Heterotheca*, I have been able to make only arbitrary morphological distinctions between var. *pedunculata* and var. *minor*.

Variety *pedunculata* is very similar to ***Heterotheca zionensis*** Semple and partly sympatric with it. Plants of *H. zionensis* are said to be identified by stems and leaves appearing silvery to whitish from densely strigose vestiture and peduncles and phyllaries usually densely glandular but otherwise glabrate. Such plants are distinguished by Semple from more densely pubescent individuals of *H. villosa* var. *minor* or from plants identified as var. *pedunculata* (with gray to silvery leaves) by glandular peduncles and phyllaries, even though plants of var. *minor* may have glandular phyllaries and populations of *H. zionensis* may

include individuals with eglandular peduncles and phyllaries—"non-glandular forms of *H. zionensis* occur in north-central Utah; glandular and non-glandular forms occur in the Utah-Arizona border region" (Semple 1987, p. 385). The geographic range of *H. zionensis* overlays the range of the western portion of var. *minor* as well as of var. *pedunculata*, and distinctions among these are unclear. It does seem clear that silvery-leaved plants are concentrated in the southwest part of the range of *H. villosa*, but if the silvery-leaved plants are representative of a geographic trend in vestiture, widely intergrading with more typical plants, then it is likely that the names *H. zionensis* and *H. villosa* var. *pedunculata* represent plants shaped by the same trend and the same underlying genetics.

Status of *Heterotheca villosa* var. *nana* and var. *scabra*

Heterotheca villosa **var. *nana*** (diploid) is almost completely overlaid in its geographic range by var. *foliosa* (diploid and tetraploid but tetraploid in its area of overlap with var. *nana*, many chromosome counts, fide Semple 1996) and by var. *minor* (diploid and tetraploid, many counts, fide Semple 1996). Variety *nana* varies considerably and probably hybridizes with *H. villosa* and *H. fulcrata* (Greene) Shinners (Semple 2006), but even so, var. *nana* is morphologically consistent and recognizable throughout its range and has previously been treated at specific rank by various botanists as *H. horrida* (Rydb.) Harms (e.g., Harms 1968, 1970; Great Plains Flora Association 1986; Dorn 1988).

Heterotheca villosa **var. *scabra*** is the westernmost taxon treated by Semple within *H. villosa*, except for the south-reaching extension of the species in California (var. *minor* fide Semple). Semple (1992) noted that var. *scabra* is closely related to the Californian endemic *H. shevockii* (Semple) Semple (originally described as *H. villosa* var. *shevockii*). It seems equally plausible that var. *nana* is closely related to var. *scabra*. All three taxa tend to have spreading leaves and strongly developed glandularity.

The geographic ranges of var. *nana* and var. *scabra* are slightly overlapping along the Utah/Colorado and northern Arizona/New Mexico borders (Fig. 3). Semple (2006) observed that "In the Four Corners area, var. *nana* grades into var. *scabra*, and collections often are difficult to place into one of the two taxa"—but I find the distinction clearer and intermediates not numerous, especially in view of the broad range and relative morphological constancy of var. *scabra*. Plants of var. *scabra* and "aff. var. *scabra*" cited by Semple at a southeastern extension of its range in trans-Pecos Texas are tentatively identified here as forms of *H. viscida* (A. Gray) Harms. New Mexico collections of var. *scabra* well east of the range illustrated in Fig. 3 (San Miguel Co., Rio Arriba Co.; cited but not mapped by Semple 1992) are better identified as var. *nana*. I have not seen records of var. *scabra* from Idaho or Colorado (as indicated on Fig. 3), but it is a distinctive entity and Dr. Semple's citations document its presence there.

Variety *nana* and var. *scabra* are distinguished by Semple by various differences (mostly foliar), and my study corroborates and emphasizes their distinction, as in the following couplet.

1. Cauline leaves usually not contorted upon drying, upper mostly lanceolate to triangular-lanceolate, acute at apex; leaf surfaces moderately to densely glandular, the glands little obscured by the sparsely strigose (nonglandular) vestiture, nonglandular hairs often restricted to midvein area (middle 1/3) of adaxial surfaces or sometimes nearly absent on both surfaces, especially on more distal leaves; phyllaries glabrous to very sparsely strigose, glandular; $2n = 18, 36$ (many counts, fide Semple 1996) _____ **Heterotheca villosa** var. **scabra**
1. Cauline leaves often contorted (margins undulate) upon drying, upper mostly oblong or oblong-lanceolate, acute to obtuse at apex; leaf surfaces moderately to densely glandular, tne glands conspicuous tnrough the sparsely hispid to hispidulous (nonglandular) vestiture; phyllaries sparsely to moderately densely strigose, glandular; $2n = 18$ (many counts; 2n = 27, one count, fide Semple 1996) _____ **Heterotheca villosa** var. **nana**

Including some features more difficult to precisely contrast, plants of var. *scabra* (in contrast to var. *nana*) have stems and leaves with much reduced non-glandular vestiture but with denser and more conspicuous glandularity, leaves differently shaped, smaller, and more widely spaced, heads relatively fewer, and phyllaries glabrous (lacking non-glandular hairs) but glandular. The two taxa are different in geography.

In their area of sympatry, var. *scabra* is distinguished from a regional, more typical form of *Heterotheca villosa* (var. *minor* fide Semple) by the following contrasts.

1. Upper cauline leaves lanceolate to triangular-lanceolate, acute at apex; leaf surfaces moderately to densely glandular, the glands little obscured by the sparsely strigose (nonglandular) vestiture, nonglandular hairs often restricted to midvein area (middle 1/3) of adaxial surfaces or sometimes nearly absent on both surfaces; phyllaries glabrous to very sparsely strigose _____ **Heterotheca villosa** var. **scabra**
1. Upper cauline leaves linear to oblanceolate, oblong-lanceolate, or narrowly obovate, acute to obtuse at apex; leaf surfaces eglandular or sparsely to densely glandular, moderately to densely strigose evenly over both surfaces; phyllaries sparsely strigose _____ **Heterotheca villosa** var. **minor**

In view of their morphological integrity and apparent reproductive isolation from elements of more nearly typical *Heterotheca villosa*, both *H. villosa* var. *nana* and *H. villosa* var. *scabra* are treated here at specific rank.

Heterotheca polothrix Nesom, nom. et stat. nov. *Chrysopsis villosa* var. *scabra* Eastwood, Proc. Calif. Acad. Sci. 2.6:294. 1896. *Heterotheca villosa* var. *scabra* (Eastwood) Semple, Phytologia 73:453. 1992. TYPE: U.S.A. UTAH. San Juan Co.: Willow Creek, 14 Jul 1895, *A. Eastwood 38* (HOLOTYPE: CAS, digital image!). Non *Heterotheca scabra* DC. 1836. The species is named for a resemblance of the medial strip of adaxial leaf vestiture to the mane of a pony (Greek, *polos*, pony, and *thrix*, hair). Blake's varietal epithet ("cinerascens," at varietal rank, as below) is poorly descriptive of the taxon (as also noted by Semple 1987).

Chrysopsis viscida A. Gray subsp. *cinerascens* Blake, Proc. Biol. Soc. Washington 35:173. 1922. *Heterotheca horrida* subsp. *cinerascens* (Blake) Semple, Brittonia 39:381. 1987. TYPE: U.S.A. UTAH. [Beaver Co.: fide Welsh 1982]: Beaver Creek, among rocks in the oak region, 2 Sep 1901, *I. Tidestrom 2873* (HOLOTYPE: US, internet image!).

Heterotheca horrida (Rydb.) Harms, Wrightia 4:17. 1968. *Chrysopsis horrida* Rydb., Bull. Torrey Bot. Club 31:648. 1905. TYPE: U.S.A. COLORADO. [Weld Co.]: New Windsor, 8 Aug 1900, *G.E. Osterhout 2326* (HOLOTYPE: NY internet image!; ISOTYPES: RM, WIS).

Chrysopsis canescens var. *nana* A. Gray, Mem. Amer. Acad. Sci. 4[Pl. Fendl.]:78. 1849. *Heterotheca villosa* var. *nana* (A. Gray) Semple, Novon 4:54. 1994. TYPE: U.S.A. NEW MEXICO. [Mora Co.?]: elevated rocky region 2 mi E of the Mora River, Aug 1847, *A. Fendler 391c* (HOLOTYPE: GH).

Status of *Heterotheca villosa* var. *sierrablancensis*

Heterotheca villosa var. *sierrablancensis* was described by Semple (1996) from the White Mountains and Sacramento Mountains of Lincoln and Otero cos., New Mexico. It is similar to *H. horrida* in its conspicuously glandular vestiture and congested and consistently corymbiform capitulescence but distinct in its leaves more densely strigose, the upper cauline ascending, larger, and differently shaped (lanceolate or oblong-lanceolate to ovate), ray corollas longer, and habitats at higher elevation. It occurs at the southeastern corner of the range of *H. horrida* (*H. villosa* var. *nana*) and Semple indicated (1996, Fig. 3) that the two taxa are most closely related to each other. Both are primarily diploids. The extended population system of var. *sierrablancensis* is morphologically variable but it lies inside the geographic range of *H. horrida* and apparently is isolated from it as well as the regional expression of *H. villosa*, both of which occur at lower elevations. Recognition at specific rank is appropriate for this taxon, especially in view of the parallel rank of *H. horrida*.

Heterotheca sierrablancensis (Semple) Nesom, comb. & stat. nov. *Heterotheca villosa* var. *sierrablancensis* Semple, Univ. Waterloo Biol. Ser. 37:146. 1996. TYPE: U.S.A. NEW MEXICO. Lincoln Co.: Sierra Blanca, NM 532 8.5 km W of NM 48, rocky outcrop and face of roadcut at switchback directly below scenic overlook, 2 Oct 1995, *J.C. Semple and Semple 10513-A* (HOLOTYPE: WAT; ISOTYPES: MO!, NMC, RM).

Status of *Heterotheca villosa* var. *depressa*.

Semple treated this narrowly endemic taxon at varietal rank because it hybridizes with var. *minor*. Both taxa are tetraploid in their area of sympatry. As noted by Semple (2006), "Var. *depressa* grows in geyser basins in Yellowstone National Park and is locally common in rocky soils in Teton National Park; it is very rare farther south in Wyoming. It is distinguished by its small stature, small heads, and linear-oblanceolate leaves with many hairs and usually some glands. It is similar to some forms of var. *minor*, which occur throughout the range of var. *depressa* and with which it hybridizes. ... Typical var. *depressa* occupies the vicinity of hot springs and geyser basins and nearby river flood banks, while var. *minor* occupies other drier or non-geyserite nearby habitats." Markow (2001,

2004) found that the occurrence of *H. depressa* is strongly correlated with that of another narrow endemic, *Stephanomeria fluminea* Gottlieb.

The geographic range of *Heterotheca villosa* var. *depressa* is relatively discrete, like that of *H. sierrablancensis*, and is essentially imbedded within the much larger distribution of *H. villosa* sensu lato. Although var. *minor* (sensu Semple) hybridizes with var. *depressa*, the latter appears to have its unique ecological niche, maintains its morphological identity, and is justifiably treated at specific rank.

Heterotheca depressa (Rydb.) Dorn, Vasc. Pl. Wyoming (ed. 1) 295. 1988. *Chrysopsis depressa* Rydb., Mem. New York Bot. Gard. 1:381. 1900. *Heterotheca villosa* var. *depressa* (Rydb.) Semple, Novon 4:53. 1994. TYPE: U.S.A. WYOMING. Teton Co.: Yellowstone National Park, Lower Geyser Basin, 7000 ft, 4 Aug 1897, *P.A. Rydberg and E.A. Bessey 5067* (HOLOTYPE: NY internet image!; ISOTYPES: CAN, NY, US internet image!).

Status of *Heterotheca stenophylla* var. *angustifolia*.

Semple (1996, 2006) has treated *Heterotheca stenophylla* (A. Gray) Shinners as comprising two varieties, var. *stenophylla* and var. *angustifolia* (Rydb.) Semple, "based on field studies and the results of multivariate analyses ... . The type of var. *angustifolia* is morphologically closer to many individuals of [*H. stenophylla*] var. *stenophylla* than it is to either *H. canescens* or typical *H. villosa*. ... At the very least, the type of var. *angustifolia* belongs in *H. stenophylla*, regardless of where the more *canescens*-like and the more *villosa*-like plants are placed" (Semple 1996, p. 94).

Previous botanists have treated var. *angustifolia* within *Heterotheca villosa* (e.g., Harms 1968, 1970; Great Plains Flora Association 1986). Harms observed (1968, p. 16–17) that "over most its range, including Texas, *Heterotheca stenophylla* appears to represent a quite distinct diploid ($n = 9$) species, but some tetraploid ($n = 18$) populations are known from a narrow band along the eastern edge of the species' overall distribution reaching from south-central Kansas to the Wichita Mountains of south-central Oklahoma (to ?Archer Co., Texas) which hybridize and intergrade somewhat with [tetraploid] *H. villosa*. As a result, the tetraploid *H. stenophylla* populations as a whole are usually distinguishable from the diploid populations by the presence of such introgressed characters from *H. villosa* as more pubescent involucres, stems, or leaves, but it seem impossible to assign individual plants to a particular ploidy level on this basis. Thus it appears impractical to attempt to taxonomically distinguish the tetraploid from the diploid *H. stenophylla* populations despite the the presence of an obvious reproductive barrier based upon different ploidy levels. Neither does it seem logical to taxonomically merge *H. stenophylla* with *H. villosa* [var. *angustifolia*] merely because certain tetraploid populations of the former hybridize more or less extensively with the latter, when most of the *H. stenophylla* taxon is diploid and clearly distinct morphologically and biologically."

Heterotheca stenophylla (sensu stricto) is broadly sympatric with var. *angustifolia* and I (with Harms) also find that the two are distinct in the field and herbarium. Triploid putative hybrids have been reported (Semple 1996, 2006). In contrast, var. *angustifolia* intergrades with broader-leaved forms of *H. villosa*, especially in Nebraska and the Dakotas, and is reasonably treated within *H. villosa*. "Inclusion of var. *angustifolia* ... only slightly increases the morphological complexity of *H. villosa*, as defined by Semple, and [it] occupies a part of the overall geographic range where its sympatry with conspecific varieties is relatively less" (Nesom 1997, p. 11).

Harms (1970, p. 1567) noted that "most of the Texas material [of *Heterotheca villosa*] belongs to var. *foliosa* (characterized by dense canescent appressed pubescence of involucres and herbage, and larger heads) or to var. *angustifolia* (characterized by narrower leaves, coarser and sparser herbage pubescence and smaller heads); these varieties intergrade on a broad scale, and much Texas material appears to be more or less intermediate between them." Still, a trend within *H. villosa* toward narrow leaves is pronounced in Texas, Oklahoma, and Kansas, and identification of these plants as var. *angustifolia* is justifiable.

1. Stems eglandular; leaves oblong oblanceolate to elliptic-oblanceolate, 3–6 mm wide, eglandular or sessile-glandular on abaxial surface, moderately to densely strigose, hairs usually without inflated basal celss; phyllaries eglandular or inconspicuously and minutely glandular; chromosome counts of $2n = 36$ (fide Semple 1996) _____ **Heterotheca villosa** var. **angustifolia**

1. Stems sessile-glandu ar; leaves linear to narrowly oblanceolate, 2 3(4.5) mm wide, sessile-glandular, sparsely hispid-strigose, hairs with conspicuously inflated and vis cid basal cells; phyllaries glandular to eglandular, sparsely strigose or essentially without nonglandular hairs; many chromosome counts of $2n = 18$, few of $2n = 36$ (fide Semple 1996) _____ **Heterotheca stenophylla**

Consistent distinction between *Heterotheca villosa* var. *angustifolia* and *H. canescens* (DC.) Shinners is sometimes more difficult than between var. *angustifolia* and *H. stenophylla*. *Heterotheca canescens* is mostly diploid, but some tetraploids have been reported, and as noted by Semple (1996, p. 97), "tetraploids [of *H. canescens* and *H. villosa* var. *angustifolia*] apparently hybridize forming local swarms of parent-like and hybrid individuals." And "in Texas, it sometimes is difficult to clearly distinguish herbarium specimens of [*H. canescens*] from certain canescent, strigose-sericeous, smaller-headed, more narrow-leaved forms of *H. villosa* (Harms 1970, p. 1568).

Heterotheca villosa (Pursh) Shinners var. **angustifolia** (Rydb.) Harms, Wrightia 4:16. 1968. *Chrysopsis angustifolia* Rydb., Bull. Torrey Bot. Club 37:128. 1910. *Chrysopsis villosa* var. *angustifolia* (Rydb.) Cronq., Bull. Torrey Bot. Club 74:150. 1947. *Heterotheca stenophylla* var. *angustifolia* (Rydb.) Semple, Novon 4:53. 1994 TYPE: (Semple 1990): U.S.A. NEBRASKA. Hooker Co.: Middle Loup River, near Mullen, on sandhills, 14 Sep 1893, *P.A. Rydberg 1766* (LECTOTYPE: NY internet image!; ISOLECTOTYPES: GH, NY, US).

Heterotheca stenophylla (A. Gray) Shinners, Field & Lab. 19:68. 1951. *Chrysopsis hispida* var. *stenophylla* A. Gray, Boston J. Nat. Hist. 6 (Pl. Lindh.):223. 1850. *Chrysopsis villosa* var. *stenophylla* (A. Gray) A. Gray, Synopt. Fl. N. Amer. (ed. 2) 1(2):123. 1884. *Chrysopsis stenophylla* (A. Gray) Greene, Erythea 2:96. 1894. TYPE: U.S.A. TEXAS. [Llano Co.]: Llano, from strong ligneous roots in crevices of smooth granite rocks, Nov 1847, *F.J. Lindheimer 631* (HOLOTYPE: GH; ISOTYPES: CAN, DS, GH, K, MO!, ND-G, NY[4 sheets, internet image!], US).

Taxonomic summary of the *Heterotheca villosa* complex

Four taxa treated by Semple as varieties within *Hetorotheca villosa* are recognized here at specific rank: *H. horrida*, *H. polothrix*, *H. sierrablancensis*, and *H. depressa*. Intergradation and sympatry among var. *villosa*, var. *foliosa*, var. *ballardii*, and var. *minor* make it impractical and biologically unrealistic to recognize them as more than a single entity. The identity of var. *pedunculata* vs. *H. zionensis* and vs. other densely hairy plants in the region of var. *minor* is not clear. Variety *angustifolia* appears to be justifiably recognized within *H. villosa* (vs. within *H. stenophylla*).

Distinct morphogeographic entities are recognized here with formal names. Relatively stable morphology and sympatry with close relatives indicate that such taxa are reproductively isolated, and they are treated at specific rank. In addition to typical *Heterotheca villosa*, var. *pedunculata* (sensu lato) and var. *angustifolia* appear to be geographically distinct but each intergrades with more typical plants where ranges meet—these latter two are tentatively regarded here at varietal rank. It might be useful to recognize widespread morphological "nodes" within var. *villosa* sensu lato at the rank of forma or with an informal name; the contrasting taxonomic approach (formal recognition of sympatric conspecific varieties) requires a majority of typological and arbitrary judgments.

Local and regional floristic studies may encounter and identity stable sympatric races that call for a more complex nomenclature than proposed here. But because of the geographic mix of hybrids and ploidy levels, biological and morphological patterns in the *Heterotheca villosa* complex may remain more complex than can be adequately circumscribed by traditional nomenclature.

1. Heterotheca villosa (Pursh) Shinners [1951]

Amellus villosus Pursh [1814, NEOTYPE: Missouri River, almost certainly North Dakota]

1a. Heterotheca villosa var. **villosa**

Including 1aa, 1ab, and 1ac. The sympatry and intergradation of var. *villosa* sensu Semple with var. *foliosa*, var. *ballardii*, and var. *minor* suggest that these taxa are arbitrarily identified.

[1aa]. *Heterotheca villosa* var. *foliosa* (Nutt.) Harms [1968]
Chrysopsis foliosa Nutt. [1841, TYPE: SW WYOMING]
Chrysopsis villosa var. *foliosa* (Nutt.) Cronq. [1947]
Chrysopsis imbricata A. Nels. [1904, TYPE: COLORADO. El Paso/Teller Co.]
Chrysopsis foliosa var. *imbricata* (A. Nels.) A. Nels. [1909]

If *Chrysopsis foliosa* var. *imbricata* is treated as synonymous with *Heterotheca villosa* var. *foliosa* (as done by Semple 1996, 2006), the earliest name at varietal rank is "var. *imbricata*." In this context, *H. villosa* var. *foliosa* is an invalid name.

[1ab]. *Heterotheca villosa* var. *ballardii* (Rydb.) Semple [1994]
Chrysopsis ballardii Rydb. [1931, TYPE: MINNESOTA. Carver Co.]

"This is the generally robust, larger-headed, many-rayed, eglandular, oblong-leaved race of the species occurring on the northeastern prairies of Canada and the United States" (Semple 1994, p. 53). "Forms of var. *ballardii* are sufficiently similar to forms of var. *foliosa* that the two taxa might be treated as convarietal races under the name var. *foliosa*" (Semple 1996, p. 114). The geographic range of var. *ballardii* lies within that of var. *villosa* sensu Semple.

[1ac]. *Heterotheca villosa* var. *minor* (Hook.) Semple [1994]
Chrysopsis villosa var. *minor* Hook. [1847, TYPE: WYOMING. Sweetwater Co.]
Diplopappus hispidus Hook. [1834, TYPE: SASKATCHEWAN. Carlton House]
Chrysopsis villosa var. *hispida* (Hook.) A. Gray [1884]
Heterotheca villosa var. *hispida* (Hook.) Harms [1974]

Canadian botanists have commonly recognized two varieties of *H. villosa*, var. *villosa* (leaves and involucres with appressed, nonglandular vestiture) and var. *hispida* (leaves and involucres with spreading hairs intermixed with glands), but none has indicated that the taxa are geographically or ecologically distinct or that intergradation and typological identifications are not prevalent in this region.

1b. Heterotheca villosa var. **pedunculata** (Greene) Harms ex Semple [1987]

Chrysopsis pedunculata Greene [1900, TYPE: COLORADO: Archeluta Co.]
?*Heterotheca zionensis* Semple [1987, TYPE: UTAH. Washington Co.]

Representing the densely strigose, silvery-sericeous expression of the *H. villosa* complex; common in Utah, northern Arizona, and the Four Corners region. As noted above, I have not been able to distinguish *H. zionensis* from var. *pedunculata*, based on criteria established by Semple.

1c. Heterotheca villosa var. **angustifolia** (Rydb.) Harms [1968]

Chrysopsis angustifolia Rydb. [1910, TYPE: NEBRASKA. Hooker Co.]
Chrysopsis villosa var. *angustifolia* (Rydb.) Cronq. [1947]
Heterotheca stenophylla var. *angustifolia* (Rydb.) Semple [1994]

Allopatric and distinct from other expressions of *H. villosa*, at least in Texas, Oklahoma, and most of Kansas, intergrading in Nebraska, South Dakota, and North Dakota.

2. Heterotheca horrida (Rydb.) Harms [1968]

Chrysopsis horrida Rydb. [1904, TYPE: COLORADO. Weld Co.]
Heterotheca villosa var. *nana* (A. Gray) Semple [1994]
Chrysopsis canescens var. *nana* A. Gray [1849, TYPE: NEW MEXICO, ?Mora Co.]

3. Heterotheca sierrablancensis (Semple) Nesom [2006]

Heterotheca villosa var. *sierrablancensis* Semple [1996, TYPE: NEW MEXICO. Lincoln Co.]

4. Heterotheca polothrix Nesom [2006]

Chrysopsis villosa var. *scabra* Eastwood [1896, TYPE: UTAH. San Juan Co.]
Heterotheca villosa var. *scabra* (Eastwood) Semple [1992]

5. Heterotheca depressa (Rydb.) Dorn [1988]

Chrysopsis depressa Rydb. [1900, TYPE: WYOMING. Teton Co.]
Heterotheca villosa var. *depressa* (Rydb.) Semple [1994]

ACKNOWLEDGMENTS

All pertinent specimens at BRIT/SMU, MO, and TEX/LL were studied, and a loan from SJNM was helpful in providing a base of study for plants of the Four Corners region. In all, more than 1350 specimens of the *Heterotheca villosa* complex were examined. Additionally, I have examined all collections of all taxa of *Heterotheca* at these herbaria. Staff at CAS provided an image of the holotype of *Chrysopsis viscida* subsp. *cinerascens* and made observations of details of its vestiture. Robert George lent his digital proficiency toward production of the maps. Constructive review comments of Vernon Harms and an anonymous reviewer are greatly appreciated.

Postcript.—Dr. John Semple has read some or all of the manuscript, and in any case, he is intensely opposed to the approach and its conclusions. But it has not seemed necessary to re-assemble and re-cite the massive number of specimens (10,300) Dr. Semple had on hand for his monographic study of sect. *Phyllotheca*. He has noted that his treatment is based on multivariate analyses (yet unpublished), and no statistics are found here (nor do I believe that taxonomic conclusions based on such an approach must necessarily be correct). I do not have the long and focused field experience he has had with this group. Still, because of our strong and basic differences in taxonomic philosophy (regarding concepts of species and varieties) and apparently because of differences in the way in which we perceive and interpret patterns of variation, it obviously is possible to differ in taxonomic conclusions regarding the same group of plants. We agree on the delimitation of some of the taxa but not others. For those we agree should be formally recognized, we disagree at what rank some should be treated. If this taxonomic overview is seen as no more than a "superficial opinion-piece," at least I have tried to provide a clear rationale for the basis of my opinions and why they differ from those of Dr. Semple. The alternative taxonomy proposed here allows me to identify plants of the *Heterotheca villosa* complex in a consistent and biologically meaningful way, from my point of view. Others also have a choice.

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TAXONOMY OF *LANTANA* SECT. *LANTANA* (VERBENACEAE): I. CORRECT APPLICATION OF *LANTANA CAMARA* AND ASSOCIATED NAMES

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ABSTRACT

The previous lectotypification of *Lantana camara* L. is evaluated by examination of characters of the lectotype, review of other original material, and documentation of current usage of the name. The current usage is analyzed by surveying pertinent literature and by sampling specimens for annotations between 1753 and the present in relation to critical characters of those specimens. Current usage of *L. camara* includes a widely cultivated and naturalized cultigen species of hybrid origin that is taxonomically distinct from *L. camara*. To determine the correct name of the cultigen, all names in *Lantana* sect. *Lantana* are reviewed, typified if necessary and possible, and taxonomically disposed. No available name applies to the cultigen, which is newly described as ***Lantana strigocamara*** R.W. Sanders. Origin of the named hybrids in the *L. camara* complex is hypothesized. Two new combinations are made, ***Lantana camara*** subsp. ***aculeata*** (L.) R.W. Sanders and ***Lantana nivea*** Vent. subsp. ***mutabilis*** (W.J. Hook.) R.W. Sanders. Nineteen lectotypifications and seven epitypifications are made.

RESUMEN

La lectotipificación previa de *Lantana camara* L. se evalúa mediante examen de los caracteres del lectotipo, revisión de otro material original, y documentación del uso actual del nombre. El uso actual se analizó revisando la bibliografía adecuada y por muestreo de especimenes entre 1753 y el presente por comentarios en relación a caracteres críticos de esos especimenes. El uso actual de *L. camara* incluye una especie ampliamente cultivada y naturalizada de origen híbrido que es taxonómicamente diferente de *L. camara*. Para determinar el nombre correcto de la planta cultivada se revisaron todos los nombre de *Lantana* sect. *Lantana*, se tipificaron cuando fue necesario y posible, y taxonómicamente decidido. No hay nombres disponibles para la planta cultivada, que se describe como ***Lantana strigocamara*** R.W. Sanders. Se hace una hipótesis del origen de los híbridos nombrados en el complejo *L. camara*. Se hacen dos combinaciones nuevas, ***Lantana camara*** subsp. ***aculeata*** (L.) R.W. Sanders y ***Lantana nivea*** Vent. subsp. ***mutabilis*** (W.J. Hook.) R.W. Sanders. Se realizan diez y nueve lectotipificaciones y siete epitipificaciones.

Plants that have gone under the Linnaean name *Lantana camara* L. are well known, not only as hardy summer ornamentals worldwide but also as naturalized weeds having devastating economic impact in humid tropical areas of the Old World (Wolfson & Solomons 1964; Howard 1970; Stirton 1977; Swarbrick et al. 1995; Day et al. 2003). The systematics of these cultivated and naturalized plants is not well understood, even though considerable effort has been made to elucidate their biological control (Day et al. 2003). This confusion arises in

part from the convoluted history of exploration, cultivation, hybridization, and artificial selection that began at least 60 years before the publication of Linnaeus' *Species Plantarum* (1753). Records that have been compiled (Howard 1969; Stirton 1977) suggest that, during the eighteenth century, fanciers hybridized different wild species and infraspecific taxa of *Lantana* L. sect. *Lantana* from Mexico, the West Indies, and Brazil. As shown in this paper, the early validly published names were based on garden-grown material (almost entirely so until 1817 and commonly so into the 1850s), much of which consisted of hybrid combinations.

As herbarium specimens of wild-collected species of sect. *Lantana* became available after the early 1800s, many of the available, poorly distinguished names were frequently misapplied to them. Adding to this confusion was the introduction of cultivated hybrids into neotropical regions where indigenous taxa occur. Due to the propensity of lantanas to undergo polyploidy and the partial fertility of odd polyploid levels (Natarajan & Ahuja 1957; Khoshoo & Mahal 1967; Spies 1983, 1984; Spies & Stirton 1982a, b, c; Sanders 1987a, b), even more complex hybrids formed between indigenous taxa and the escaped hybrid cultigens (Sanders 1987a, b, c, 1989a). Thus, the limits of natural variation have been obscured, hampering the ability of taxonomists to develop effective classifications for the group.

Schauer (1847), Briquet (1895), and Troncoso (1974) developed current sectional concepts. Species of *Lantana* sect. *Lantana* (=sect. *Camara* Cham.) are characterized by predominantly narrow floral bracts that are somewhat inconspicuous among the tubular corolla bases, by usually yellow or orange pigmented corollas (white-flowered populations known in several species [unpubl. observ.]; see also discussion below concerning purplish pigments in the section), and by blackish drupes. Each drupe contains a characteristically inflated compound endocarp that resembles a horse's skull in which the seed chambers are in the position of the eye sockets. Some of the species of the other major section, *Lantana* sect. *Callioreas* Cham., might be confused with those of sect. *Lantana*. Generally, species of sect. *Callioreas* are described as involucrate, usually having ovate to reniform conspicuously imbricate floral bracts and purplish corollas. However, fruits are needed to insure correct sectional placement—drupes are usually white or purplish and endocarps are subglobose, bilobed (seed chambers fill each hemisphere), noninflated, and reticulately ornamented.

Schauer (1847) published the only worldwide revision of *Lantana* in De Candolle's *Prodromus*. All more recent work has been limited to regional and garden floras. The foremost student of Verbenaceae in the twentieth century, Harold N. Moldenke, never produced a revision of *Lantana*, but he did describe a number of new species and infraspecific taxa. Horticulturalists, ecologists, and some floristic taxonomists have effectively submerged much of *Lantana* sect. *Lantana* into *L. camara*, treating this wide spectrum of variation as a single

species, (e.g., Kuntze 1891; Troncoso 1965, 1974; Bailey Hortorium 1976; Schemske 1976, Huxley et al. 1992; Cullen et al. 2000).

Sanders (1987a, b, c, 1989a, b) undertook a study of the variation of wild and naturalized populations of *Lantana* sect. *Lantana* in Florida and parts of the West Indies. By correlating chromosome numbers and meiotic behavior with morphology, he was able to distinguish the natural (often diploid) wild taxa from the naturalized and spontaneous hybrids and to develop morphological taxonomic criteria. Sanders found that plant architecture, leaf and bract size and shape, indument features, inflorescence/infructescence development and size, fruiting bract persistence, and floral pigment classes and dosage effects correlate well with cytology, geographic distributions, and species delimitations. On the other hand, he argued that development of prickles and specific corolla colors, characters relied upon by many other authors, vary too widely within and among taxa to be effective criteria, a conclusion recently supported by molecular studies (Scott et al. 1997; Day et al. 2003). Further support comes from the work of Isidro Méndez S. of Cuba who took up the study of Cuban and West Indian Verbenaceae (1992, 1993, 2002). Méndez explicitly accepted the taxonomic criteria proposed by Sanders for *Lantana* sect. *Lantana*.

The natural taxa of sect. *Lantana* fall into three separate phenetic groups (to be validated in a subsequent paper; cladistic status not yet determined) on the basis of trichome structure on the abaxial surface of the leaf blades, as well as shape, adaxial luster, and venation of the leaf blades. The "pilose-morph" species (Pilose Group, Fig. 1) are characterized by soft, filiform, spreading (erect or curly) hairs usually densely disposed on all veins and intervening tissue. Most of these have leaf blades that are broadly ovate to narrowly deltate, rounded to cordate at the base and acuminate to obtuse at the apex, dull above (epidermis poorly reflective), and more or less pinninerved. The "strigose-morph" species (Strigose Group, Fig. 2) have the abaxial hairs developed as conspicuous strigae, i.e., the hairs are stout, conical, antrorsely geniculate, and are scattered and restricted to the midrib, and secondary, tertiary, and sometimes higher order veins, but not to the intervening tissue. Leaf blades are usually ovate-elliptic, often tapering at base and apex, lustrous above, and more or less triplinerved. The "setose-morph" species (Setose Group, Fig. 3) abaxially bear well-separated, long, flexible to subrigid, spreading, setiform trichomes that are more or less restricted to the midrib and secondary and tertiary veins. Otherwise they are like the pilose-morph species. Thus, even though all three groups have adaxial strigae, the Stigose Group is the only one with strigae on both surfaces.

Despite Méndez's (2002) acceptance of Sanders' criteria, he disagreed with Sanders over the application of the name *L. camara*. Because *L. camara* is the proposed type of the genus (Jarvis 1992; Jarvis et al. 1993) and one of the two oldest names in the secton, the correct application of most other names in the

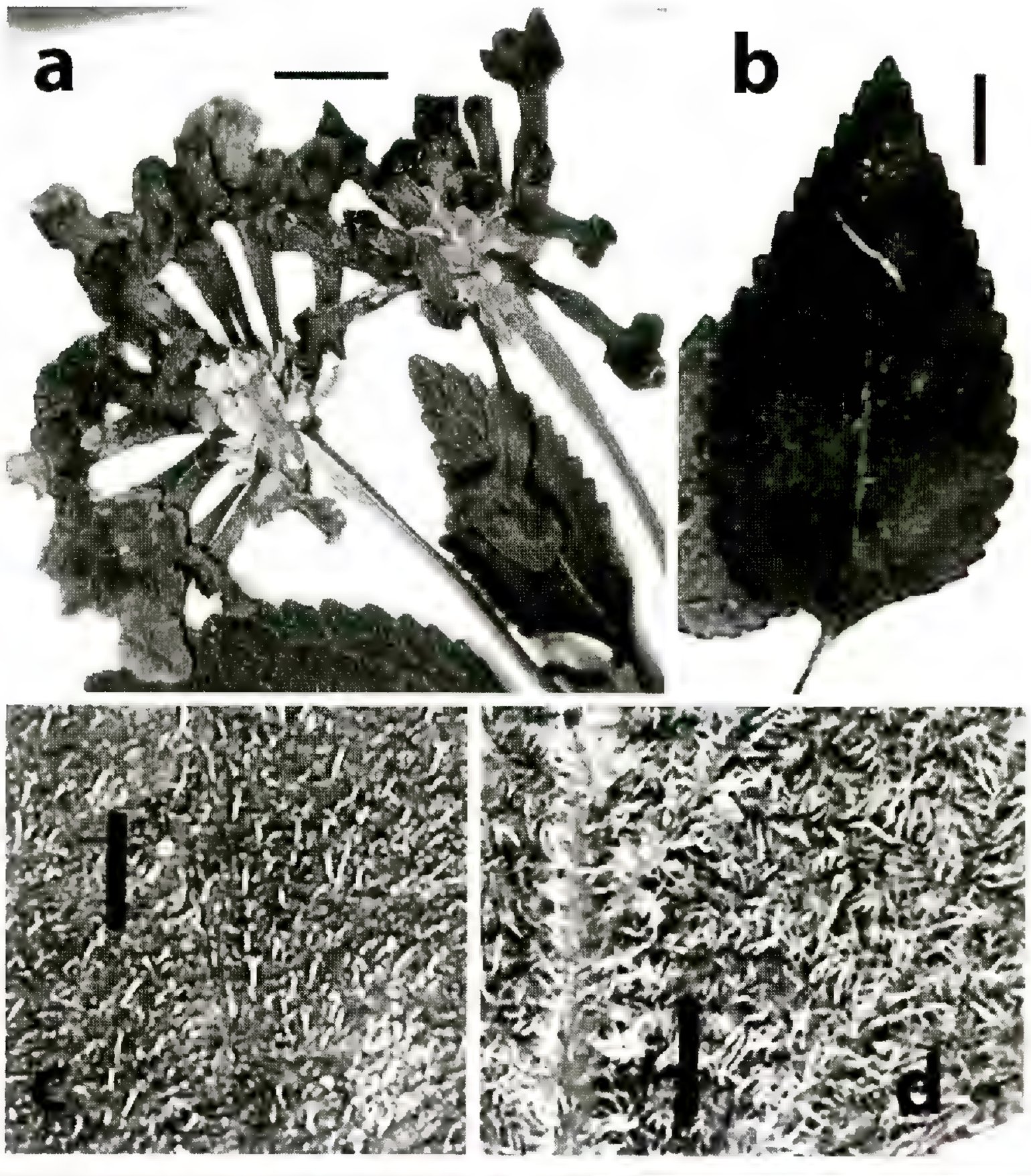


FIG. 1. *Lantana camara*, lectotype (LINN 783.4), representing Pilose Group. **a.** inflorescence. **b.** representative leaf blade. **c.** adaxial leaf surface. **d.** abaxial leaf surface. Scale bars: a & b = 5 mm; c & d = 1 mm.

section hinge upon the correct application of *L. camara*. Asserting that Sanders had committed two errors, Méndez stated:

> Sanders (1989[a]) attributed this binomial [*L. camara*] to a phenotype very different from prevailing opinion among the authors later to Linnaeus and not in agreement with the lectotype selected by Moldenke & Moldenke (1983).

However, until the present study, analysis of the lectotype and subsequent application of the name have not been straightforward. The critical characters were not visible on the lectotype since all of its leaves were mounted adaxial side up. Sanders (unpubl.) was not able to determine whether the lectotype matched the pilose-morph or the strigose-morph plants, especially given the quality of the microfiche and xerographic images available at the time. However, because H. N. Moldenke had selected the type, Sanders (unpubl.) relied primarily on the numerous annotations of Dr. Moldenke (Table 1, App. B, see also Moldenke 1980a) to develop a concept of the species and apply the name. Sanders' concept was further reinforced by annotations of C.D. Adams, and the

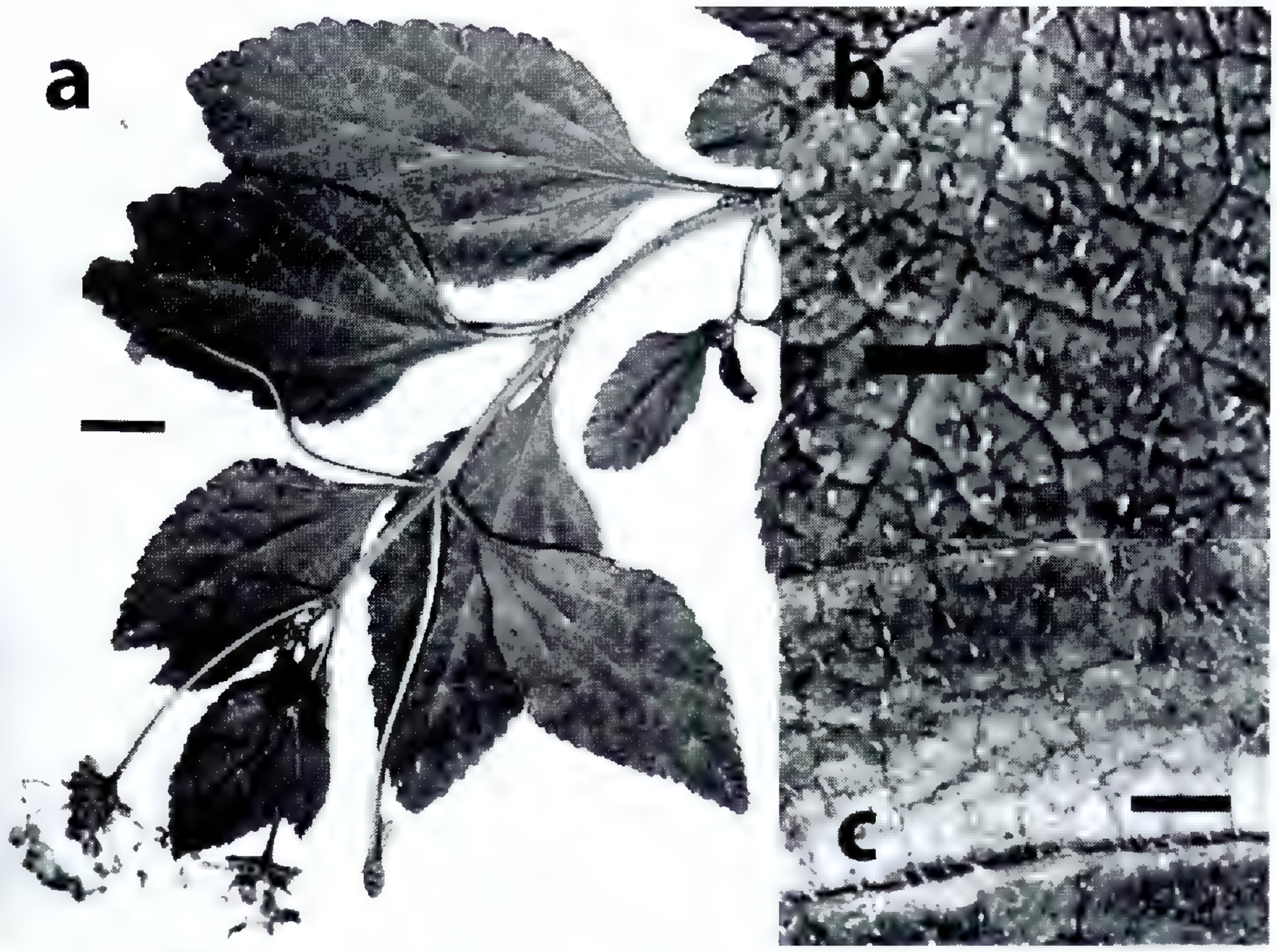


FIG. 2. *Lantana scabrida*, lectotype (*Solander s.n.?*, BM), representing Strigose Group. **a.** inflorescence and representative leaves. **b.** adaxial leaf surface. **c.** abaxial leaf surface. Scale bars: a = 1 cm; b & c = 1 mm.

treatments of *Lantana* in *The Flowering Plants of Jamaica* (Adams 1972) and *A Flora of Tropical Florida* (Long & Lakela 1971), as well as on identified cultivated material received under that name from the U.S. National Arboretum, Longwood Gardens, and reputable commercial nurseries. In all cases, the plants were characterized by leaves dominated by strigose-morph hairs, cordate-ovate blades, and dull upper surfaces[1] (here subsequently called the "**S**trigose-**C**ordate-**D**ull-" or "SCD cultigen"; Fig. 4). In the West Indies, some wild-collected specimens bear codominant mixtures of both hair morphs. However, cytological study confirmed these to be hybrids between the SCD cultigen and native taxa of the Pilose Group (Sanders 1987b). Thus, Sanders concluded that the lectotype had the strigose-morph hairs, and he applied the name *L. camara* specifically to the SCD cultigen. Many of the described species in the Pilose Group (including *L. horrida*, *L. tiliifolia*, and *L. arida*) he lumped into a single species and applied the name *L. urticifolia* Mill.

Méndez appears to have studied more recent, higher quality images in connection with a project to lectotypify Linnaean species of Verbenaceae of the West Indies in collaboration with Steve Cafferty of the Linnaean Typification Project (Méndez & Cafferty 2001). Although he, too, was unable to see the abaxial surfaces, he concluded on other grounds that the lectotype matched the pilose-

[1]Adams included in his concept of *L. camara* the SCD cultigen and *L. scabrida*. The few specimens of *L. scabrida* that I studied and bear his annotation as *L. camara* actually have lustrous upper leaf surfaces.

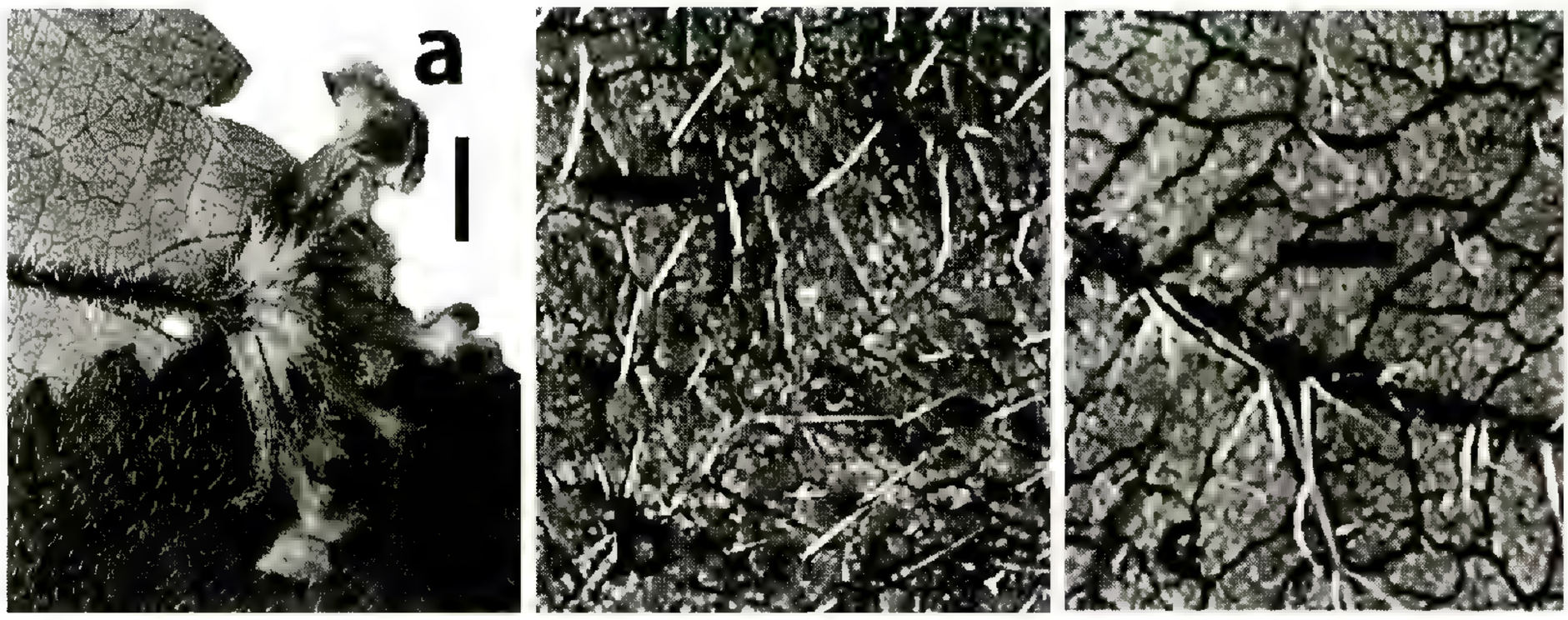


FIG. 3. *Lantana hirsuta* (*Hinton 20499*, TEX), representing Setose Group. **a.** inflorescence. **b.** adaxial leaf surface. **c.** abaxial leaf surface. Scale bars: a = 5 mm; b & c = 1 mm.

morph, not the strigose-morph plants. He applied the name *L. camara* to the taxon to which Sanders applied the name *L. urticifolia*.

If Méndez's two assertions merit redress, then another, later-published name should be applied to the SCD cultigen that Moldenke, Adams, and Sanders called *Lantana camara*. Of course, current usage, regardless of usage by authors of the early post-Linnaean period, must be established. If current usage of *L. camara* has clearly replaced the Linnaean concept with the concept of the SCD cultigen, then conservation of the nomenclatural type could serve as an alternative solution.

Therefore the purpose here is to 1) evaluate the lectotypification by reviewing its publication, by clarifying the characters of the lectotype, by understanding current usage of *L. camara*, and by determining any variance between the type and current usage; 2) affirm the correct application of that name, 3) if necessary, determine which other name is to be applied to the SCD cultigen, and 4) dispose of all other names, known to me, that are applicable to the complex.

Typification of *Lantana camara*

Moldenke and Moldenke (1983) effectively lectotypified *Lantana camara* by citing LINN 783.4 as "type" (ICBN, Art. 7.11, Greuter et al. 2000). This lectotypification was accepted by Sanders (1989b) and Méndez (2002). In March, 2004, I visited BM, and Dr. Charles Jarvis, long-time participant in the Linnaean Typification Project, consented to break the lower stem to permit study of the abaxial surface of the lowest two leaves (Fig. 1). The type, indeed, is of the pilose-morph and is verified by leaf shape and inflorescence structure as an element of the naturally occurring species distributed from the Bahamas and Greater Antilles, through Mexico south to northwestern South America. Thus of Méndez's two assertions, the one that "Sanders (1989) attributed this binomial to a phenotype...not in agreement with the lectotype selected by Moldenke and Moldenke (1983)" is correct.

TAB. 1. Data documenting history of annotation by H.N. Moldenke and other taxonomists familiar with the classification of *Lantana*. "v. moritz" indicates plants annotated as *L. camara* var. *moritziana*. See text for further discussion.

Years	Authorities	N	Pilose	%	Mixed	%	Strigose	%	Setose	%
1981–2005	Moldenke (incl. v. moritz)	62	15	24%	20	32%	27	44%	0	0%
	Moldenke (excl. v. moritz)	47	0	0%	20	43%	27	57%	0	0%
	Other	45	0	0%	25	56%	20	44%	0	0%
	All (incl. v. moritz)	107	15	14%	45	42%	47	44%	0	0%
	All (excl. v. moritz)	92	0	0%	45	49%	47	51%	0	0%
1956–1980	Moldenke (incl. v. moritz)	153	13	8%	56	37%	83	54%	1	1%
	Moldenke (excl. v. moritz)	141	1	1%	56	40%	83	59%	1	1%
	Other	60	0	0%	41	68%	19	32%	0	0%
	All (incl. v. moritz)	213	13	6%	97	46%	102	48%	1	0%
	All (excl. v. moritz)	201	1	0%	97	48%	102	51%	1	0%
1931–1955	Moldenke	16	2	13%	6	38%	7	44%	1	6%
	Other	1	0	0%	0	0%	1	100%	0	0%
	All	17	2	12%	6	35%	8	47%	1	6%
1906–1930	All	16	0	0%	10	62%	6	38%	0	0%
1881–1905	All	4	0	0%	3	75%	1	25%	0	0%
1856–1880	All	2	0	0%	0	0%	2	100%	0	0%
1831–1855	All	3	1	33%	1	33%	1	33%	0	0%
1753–1830	All	15	10	67%	2	13%	1	7%	2	13%



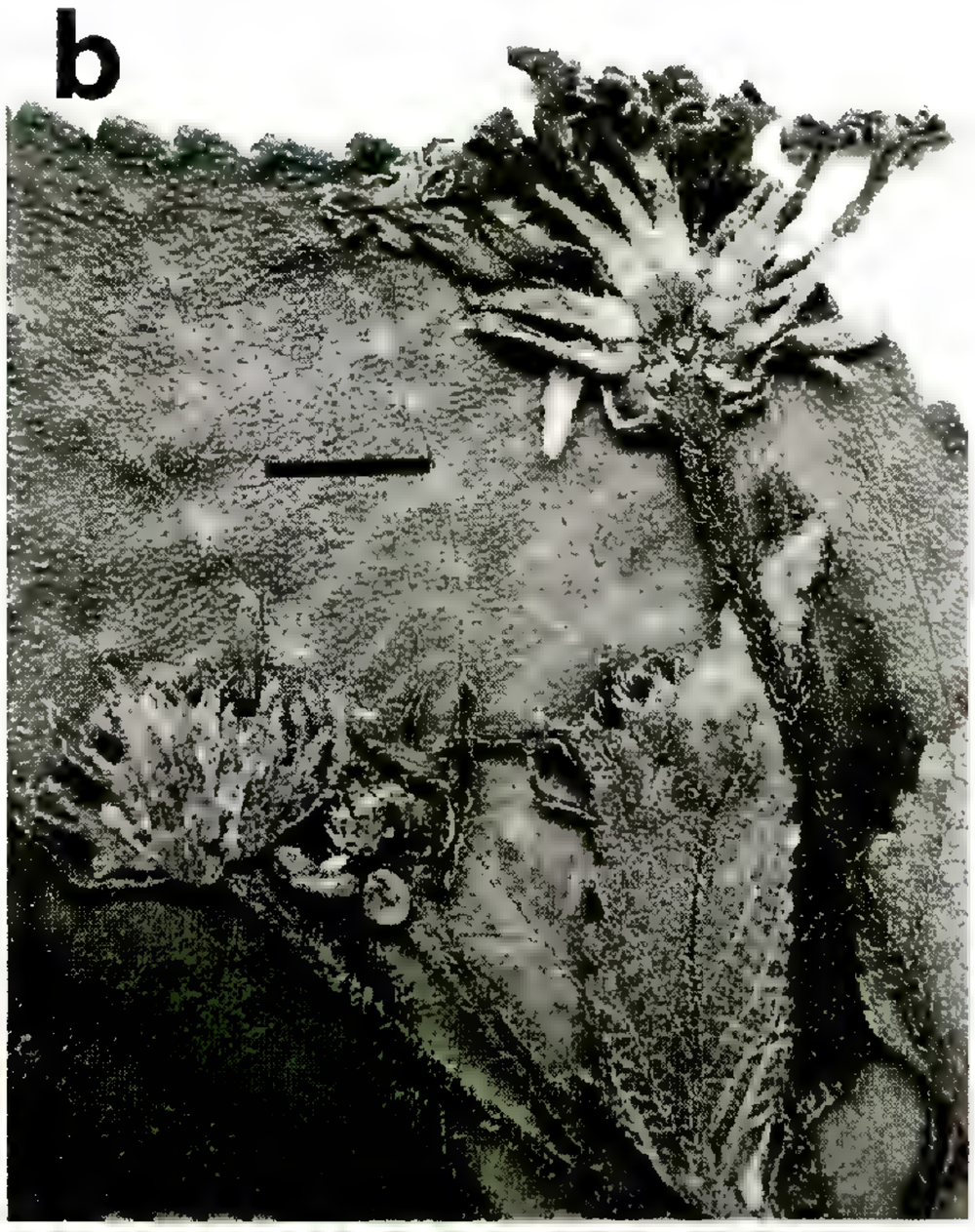






FIG. 4. *Lantana strigocamara*, holotype (*Sanders 1450*, FTG). **a.** inflorescences and representative leaves. **b.** inflorescence. **c.** adaxial leaf surface. **d.** abaxial leaf surface. Scale bars: b = 5 mm; c & d = 1 mm.

Development of current usage

Linnaeus' concept of *L. camara* was developed from an array of cultivated and horticulturally selected plants. The synonyms and illustrations that he cited in the protologue are based on vouchers that are primarily elements of the Pilose Group. All Hortus Cliffortianus (1737) specimens are either the same species as LINN 783.4 (319 Lantana 1-B!, Linn. Herb. specimen at S [a cut-down Herb. Cliff. specimen, C. Jarvis, pers. comm., dig. photo!]), are hybrids between that taxon and the Strigose Group (319 Lantana 1!), or are elements of *L. horrida*

Kunth (319 Lantana 1-C!, 1-D!, and 320 Lantana 1α![the latter possibly hybridized with the Strigose Group]). Moreover, an unnumbered Herb. Cliff. sheet (!) is an element of the Strigose Group (*L. splendens* Medik.).

Linnaeus did not see the vouchers for the syntype illustrations. One of these (icon in Plukenet, Phytographia 385. t. 114, f. 4. 1691. [Voucher: 98:143 top-left specimen, BM-SL!]), belongs to the Setose Group (*L. hirsuta* M. Martens & Galeotti). The Commelin syntype has no known voucher (C. Jarvis, pers. comm.), illustrates only an inflorescence, and cannot be placed to trichome-morph. Even so, the trichome characters may not have been of much concern to Linnaeus. For example, in 1767, he did segregate *L. mista*, which has distinctly hispid twigs, as depicted in a Dillenius plate (see App. B), which he cited. However, Linnaeus did not use this character to differentiate the new species, but rather used the protracted leaf-blades, longer bracts, and capitula with mixed corolla colors. According to C. Jarvis (pers. comm.), no other original material is known.

To determine how this somewhat broad Linnaean concept was modified by later botanists, I present two lines of evidence. The first is a survey of sampled specimens to determine annotation patterns by taxonomists (Table 1, Fig. 5). The specimens are all those annotated by H. N. Moldenke as *L. camara* in LL/TEX (including the Moldenke Herb.) and BRIT/SMU, a selection of those at K, and a few for which I obtained photographs at BM, LINN, and OXF. Besides Moldenke, annotating authorities include: Linnaeus, Medikus (implied by citation, 1775), Schauer, Urban, Merrill, Hutchinson, R. Meikle, J. K. Morton, R. Fernandes, B. Verdcourt, G. Bromley, and S. Atkins. Dr. Méndez and I are excluded.

Plants annotated as *L. camara* (or in a few cases as L. aculeata, see App. B) were scored for whether trichomes on the abaxial surface were pilose-morph only, strigose-morph only, setose-morph only, or codominant mixtures of strigose- and pilose-morphs (including rare mixtures of strigose- and setose-morphs). Between the Linnaean period, when *L. camara* was applied primarily to pilose-morph plants, and the late nineteenth century, specialists began to apply the name primarily to the strigose-morph plants or those with mixed trichome morphs. For those annotated specimens from the neotropics, the mixed trichome plants are presumed hybrids primarily between the naturalized SCD cultigen and native species of the Pilose Group. In the paleotropics, the mixed-trichome plants appeared to be either 1) hybrids between escaped pilose-morph plants and the SCD cultigen, 2) escaped cultivars selected from hybrids between *L. camara* and various species of the Strigose Group, or 3) naturalized plants consisting of complex spontaneous hybrids between plants of the preceding two categories.

As this annotation trend developed, the plants of the Pilose Group began to be annotated with other later names. In particular, note the quotation of H. Moldenke [apparently in personal correspondence] by Howard (1969):

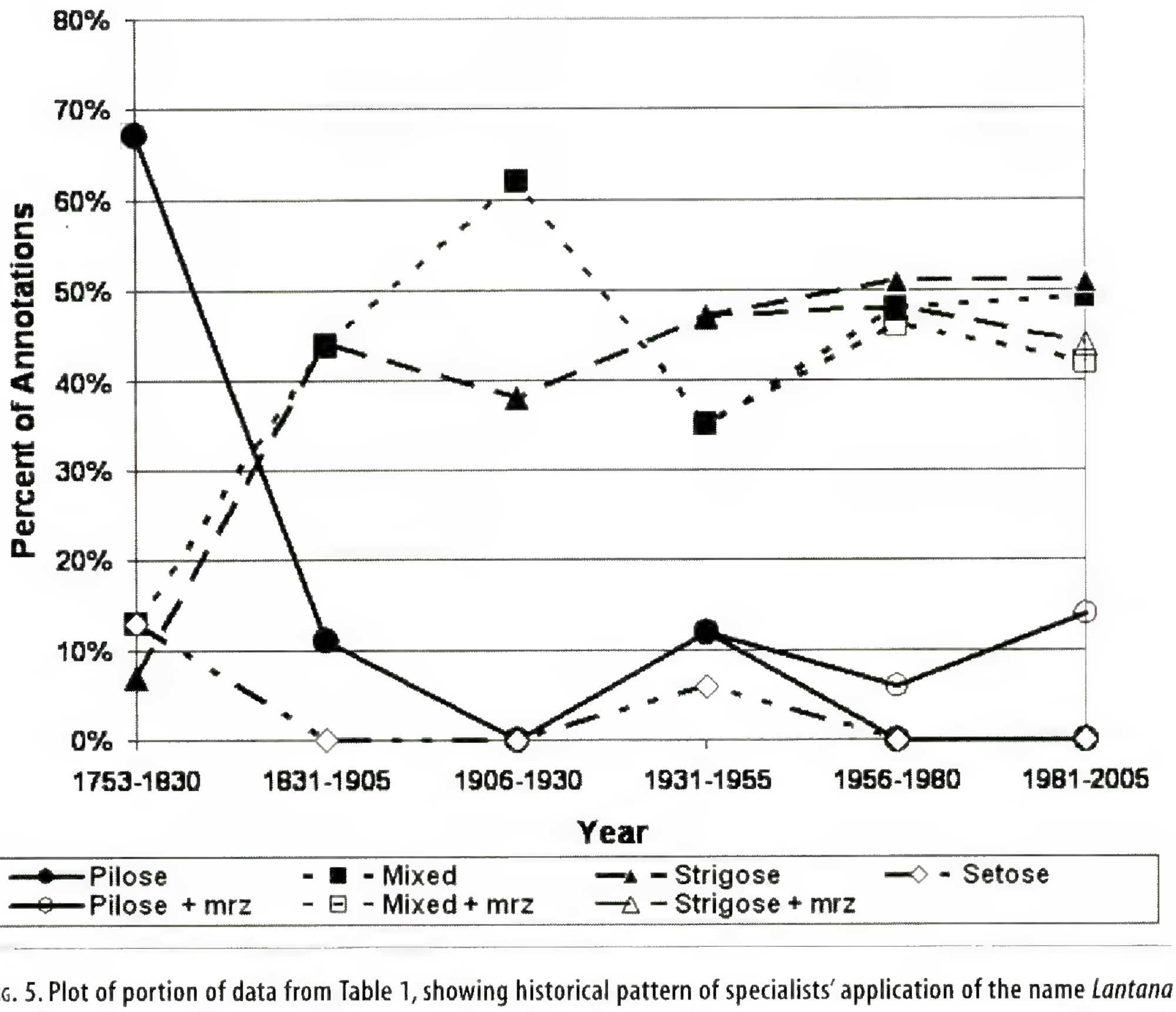


Fig. 5. Plot of portion of data from Table 1, showing historical pattern of specialists' application of the name *Lantana camara* to pilose-morph taxa (mostly *L. camara,* some *L. horrida* and their hybrids) vs. strigose-morph taxa (mostly *L. strigocamara, L. nivea*, and *L. scabrida*) vs. hybrids between the two groups (mixed morph plants) vs. setose-morph plants (mostly *L. hirsuta*). "+ mrz" indicates the inclusion of specimens annotated as *L. camara* var. *moritziana*.

You cannot depend on the accuracy of identification on the labels of plant specimens marked 'Lantana camara' in herbaria. I have found that a large percentage of such material is actually *L. moritziana, L. glandulosissima, L. scorta, L. horrida, L. arida, L. glutinosa*, etc. etc.

In other words, authorities (e.g.., Moldenke and others) attributed specimens of *L. camara* to other species names referable to the Pilose Group. Surprisingly, in the mid 1970s, Dr. Moldenke accepted López-Palacios' (1974) reduction in rank of *L. moritziana* as a variety of *L. camara*. If that anomaly is excluded from the analysis, then the application of *L. camara* to strictly pilose-morph plants by taxonomic specialists is negligible over the last 50 years.

The second line of evidence is a survey of the literature (App. A). Adequate descriptions of leaf indument are scarce prior to the 1850s, but those by Medikus (1775), Sprengel (1825), and Schauer (1847, 1851) all indicate a prevailing acceptance of plants with the abaxial surfaces soft-hairy. The first publication diverging and treating strigose-morph plants as *L. camara* is by Otto and Dietrich (1841). This reflected a growing confusion as to what *L. camara* really is. By the

beginning of the twentieth century, most horticultural taxonomists took a broad concept of *L. camara* to include both pilose- and strigose-morph (or even setose-morph) plants in the species. This sentiment is reflected in Bailey's Cyclopedia (1900):

> Lantanas have been long in cultivation, and it is difficult to refer the garden forms to botanical species. The species themselves are confusing. Most of the garden kinds are of the *L. Camara* type. There are several Camara-like species which probably have hybridized to produce these forms; but Voss [1896], the latest garden monographer, regards these species as only forms of *L. Camara* (preferring, however, to use the name *L. aculeata*). Accepting *L. Camara* in Voss's sense, the garden lantanas may be said to be derived from that species; and this view is adopted below.

Over the last 100 years, most floristic taxonomists (and hence, ecologists) have developed a similar attitude and broad concept or have followed Moldenke (1970) and Adams (1972), applying *L. camara* to the SCD cultigen and its hybrids, as has Sanders. Therefore, Mendez's other assertion that "Sanders (1989) attributed this binomial to a phenotype very different from prevailing opinion among the authors later to Linnaeus" is inaccurate.

Disparity between the lectotype and current use

The disparity between the lectotype and current use can be viewed in two ways. Either the current usage 1) includes the type and encompasses both pilose- and strigose-morph plants, or 2) excludes the type and is applied only to the SCD cultigen (and its hybrids with other species). The first view is problematic because the SCD cultigen behaves as a species distinct from the species named *L. camara* by Linnaeus. The second view raises the issue of relectotypifying *L. camara* to fit current usage. This might be preferable if LINN 783.4 were a horticultural hybrid no longer extant. However, the type is an element of a widespread wild species to which the name *L. camara* has been properly applied, at least in part, by taxonomists Standley (1924), Leon & Alain (1957), Macbride (1960), Gibson (1970), Nash & Nee (1984), López-Palacios (1977), Méndez (2002), and many ecologists. Futhermore, neither original material nor vouchers for cited illustrations consists of the SCD cultigen, and most of these specimens are of the pilose-morph (see preceding section). Therefore, overturning the choice of LINN 783.4 is not supported.

Correct name of the widespread SCD cultigen

To rectify the common practice of misapplying the name *Lantana camara* to the widespread SCD cultigen and to implement Méndez's recommendation that "...the system established by Sanders around *L. camara* should be reinterpreted," an attempt has been made to locate, to examine and, when needed, to choose nomenclatural types of all other published names in sect. *Lantana* (App. B). The results demonstrate that other names, also, have been misapplied by a number of specialists, including Schauer, Moldenke, Sanders, and Méndez.

With regard to the abaxial leaf indument, the SCD cultigen is essentially

outside the range of variation of *Lantana camara* but within the range of the Strigose Group (Fig. 4, 12). Thus, it would be imprudent to submerge this widely naturalized, aggressive species of hybrid origin as an infraspecific taxon of *L. camara*. Rather, the SCD cultigen more likely has a complex parentage involving *L. nivea* Vent., *L. scabrida* Sol. *in* Aiton, and *L. splendens* of the Strigose Group, as well as *L. camara*, and possibly other species (noteably, *L. hirsuta* of the Setose Group). Morphologically, it retains only the leaf shape and adaxial surface dullness of *L. camara*. Given the protracted history of collection and publication of new taxa, it is surprising that none of the available names can be verified as applying to this widespread cultigen. Apparently, this is due to there being so many published names and to the confused state of the taxonomy of sect. *Lantana*.

Through uncritical analysis of vague descriptions, one could argue that a few of the names that lack known types could be applied to the cultigen. However, taxonomic stability is more important than unsubstantiated priority. Assigning a neotype to a name whose concept can never be known with certainty in order to honor early taxonomists, who never understood the complexity of these plants, would be imprudent. Such names were never taken up and have no precedence of usage in the horticultural and ecological communities that taxonomists attempt to serve.

As a species of hybrid origin, of which that origin remains obscure, the SCD cultigen must be treated as a *species nova*. To provide taxonomic and bibliographic continuity, thus maximizing stability, the new epithet proposed here is based on the root "-camara." To indicate its hybrid nature and complex hypothesized parentage involving several species of the Strigose Group, it is given the prefix "strigo-"to produce *Lantana strigocamara*. At least two infraspecific epithets, and perhaps others, could serve as basionyms. However, epithet priority is mandatory only within rank, and I chose a new species name. *Lantana camara* L. var. *rubella* Moldenke (1949) is not widely known, and applying it to the whole of the species would broaden Moldenke's concept considerably. *Lantana flava* Medik. f. *sandersii* Méndez (2002) is only four years old and has not been taken up outside Méndez's own work. Raising it to species level would be tantamount to honoring myself.

Lantana strigocamara R.W. Sanders, sp. nov. (**Fig. 4**). TYPE: U.S.A. FLORIDA: Dade Co.: near intersection of Montgomery St. and Old Cutler Rd, Montgomery Botanical Center, disturbed edge of rock pineland, 23 Sep 1981, *Sanders 1450* (HOLOTYPE:: FTG! [Dig. photo! see Fairchild Tropical Botanic Garden 1999]; ISOTYPE: NY!; Drawing, Sanders 1987, fig. 9).

Credita hybridogena de *Lantana camara* L. et *L. nivea* Vent. et *L. scabrida* Sol. *in* Aiton et *L. splendenti* Medik. et *L. hirsuta* M. Martens & Galeotti mixta simulat speciem. Differt a *Lantana camara* laminis foliorum subtus strigosis, trichomatibus remotis non nisi nervis mediis secondariis tertiariisque insidentibus angustate conicis antrorse geniculatis; a *L. nivea* et *L. scabrida* et *L. splendenti* laminis magis rugosis, base abruptius contractis, pinninervibus, superficiebus hebetibus haud nitidis; a *L. nivea* trichomatibus longioribus magis conspicuisque, corollis effectis pigmentis flavis vel aureis; a

L. hirsuta trichomatibus laminarum subtus nonsetiformibus angustate conicis antrorse geniculatis; a *L. depressa* Small (specie similari) laminis nec oblongis nec ellipticis haud conduplicate incurvatis amplisque, bracteis angustioribus attenuatisque, capitulis amplis.

Strict to lax, branched, erect, rounded or scandent shrub to 3 m tall (climbing much higher in some areas of the paleotropics); twigs hirtellous, angled, with or without prickles. Petioles 5–10 mm long; blades cordate to ovate, 3–10 × 2–6 cm, mostly 1–1.7 times longer than wide, the base abruptly narrowed onto petiole, the apex acuminate, moderately rugose between higher orders of veins, dull above; hairs of adaxial laminar surface 0.3–0.7(–1.2) mm, scattered, in the form of antrorse strigae, often from pustulate bases; hairs of abaxial laminar surface usually 0.5 mm or less, stout, in the form of attenuately conical, geniculately antrorse strigae, but not closely appressed to surface, not deciduous, usually restricted to and scattered on midrib, secondary and tertiary veins (in some populations small erect hairs 0.1–0.2 mm long weakly developed on smallest veins and along crevice under larger veins); abaxial sessile glands green or not visible with 10× lens; teeth 15–25 per side, obtuse to short-acuminate, not revolute. Inflorescences 2–3 cm in diameter; peduncles 2–10 cm long; receptacle fistulose; bracts mostly 3–8 mm long, subulate, long-triangular or narrowly lanceolate (single outer series sometimes longer and narrowly spathulate or rarely subfoliaceous), apically attenuate, puberulent or hirtellous abaxially only, deciduous in fruit. Calyx 3 mm long, membranous; corolla yellow, orange-red, white, or pink to deep reddish purple and often mixed with orange or crimson, the throat often yellow, the tube 7–12 mm, slightly curved, the limb 6–10 mm across. Drupe ca. 5 mm across, blue-black; endocarp obovoid, inflated.

Paratypes: **BURMA:** Chantaburi, Makam forest, 26 Aug 1966, *Larsen et al. 1841* (AAU, LL!). **CHINA. Kwangsi:** Kweilin, cult., 1979, *Wan & Chow 79180* (LL!). **INDIA.** Lucknow, cult., 28 Oct 1974, *Shivarajan 85750* (LL!). **PAPUA NEW GUINEA. East Sepik Dist.:** Wewak, 31 Aug 1968, *Krauss 1287* (LL!). **SRI LANKA. Sabaragamuwa Prov.:** Kegalle: Kalugahatenne, 12 Feb 1974, *Moldenke et al., 28331* (LL!,US!). **UGANDA.** Paraa, 29 Jul 1972, *Moldenke & Moldenke 26073* (LL!). **USA. Florida. Dade Co.:** Homestead, 18 Jul 1966, *Smith Fl. 6* (BRI, LL!). **New York. Westchester Co.:** Yonkers, cult., 23 Sep 1950, *Moldenke 21133* (LL!).

Hypothesis of the history of the cultivated *Lantana camara* complex

Prior to the Linnaean period, the following species (citations in App. B) were already in cultivation in Europe, as deduced from the Sherard specimens at OXF, the Sloane and Clifford Herbaria at BM, and the Linnaean Herb. at LINN and S:

Pilose group	*Lantana camara* (Fig. 1, West Indies and Mexico to northern South America)
	Lantana. horrida (Fig. 8, including *L. tiliifolia*, Mexico to Argentina)
Strigose group	*Lantana nivea* (Fig. 7, southern Brazil to Argentina)
	Lantana scabrida (Fig. 2, West Indies, Mexico)
	Lantana splendens (Fig. 6, Bahamas)
Setose group	*Lantana hirsuta* (Fig. 3, Mexico)

All these species, except *L. nivea*, are characterized by capitula single in the leaf axils with stout peduncles and with corollas opening yellow and changing

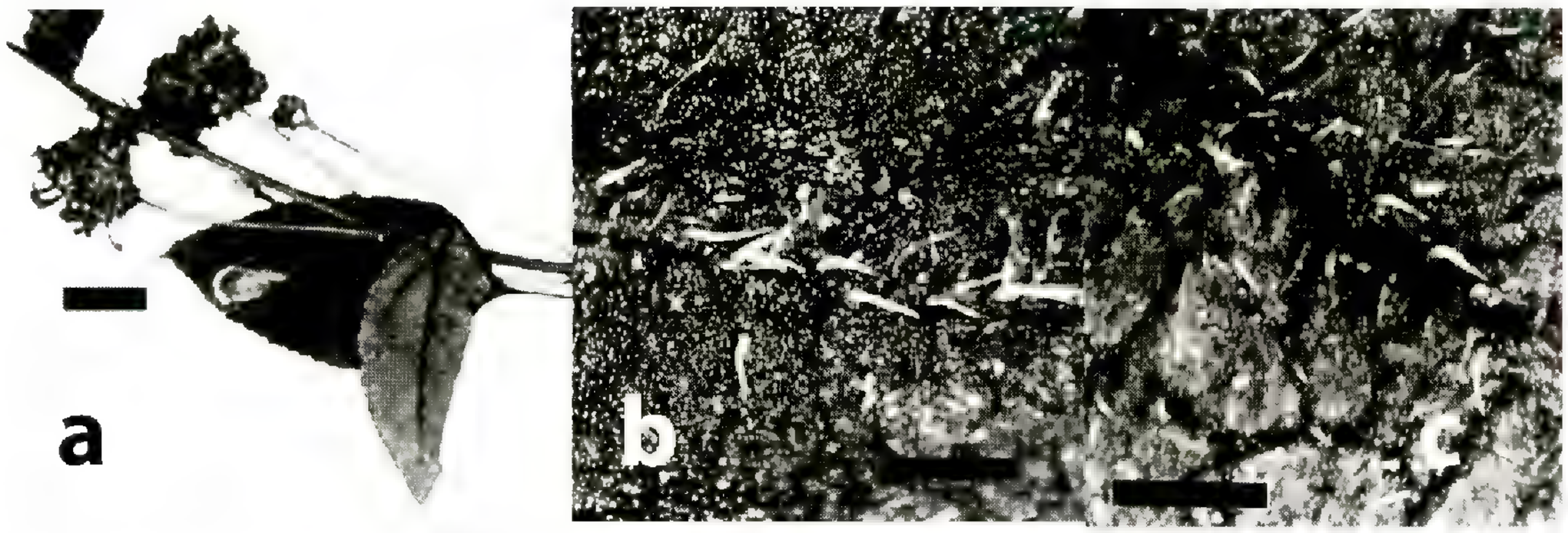


Fig. 6. *Lantana splendens*, epitype (Herb. Sherard 1269, OXF), **a.** inflorescence and representative leaves. **b.** adaxial leaf surface. **c.** abaxial leaf surface. Scale bars: a = 1 cm; b & c = 1 mm. Photographs supplied by OXF and used by permission.

to darker yellow, orange, or red-orange, and are aculeate or not. To my knowledge, *Lantana nivea* is exceptional among the natural species in having capitula commonly paired in the leaf axils with filiform peduncles and with corollas opening white and aging bluish, rose or purple, or opening pink and aging purplish. The plants are usually aculeate with recurved prickles, sometimes fiercely so. Therefore the only source in the cultivated complex for capitula opening yellow or cream and changing to purplish reds or orange plus purple would be hybridization between *L. nivea* and one or more of the other species. Parentage involving *L. nivea* is also consistent with stoutly recurved prickles in some of the cultivated hybrids. Apparently by backcrossing *L. camara* into such hybrids, plants with the mixed-colored capitula were developed within the range of variation of *L. camara* with respect to other characters (Fig. 9). Such plants I consider to be the subspecies combination *L. camara* subsp. *aculeata*. I am recognizing subspecies here and elsewhere in the complex for the following reasons: 1) the rank *varietas* in *Lantana* sect. *Lantana* has been overused for cultivars, and the varietal names are largely misapplied; 2) there may be yet undiscovered variety epithets that would take priority and further destabilize the nomenclature; and 3) I recognize the subspecies rank for geographically widespread infraspecies that comprise varieties, and further research will likely reveal localized geographic races that may warrant recognition at the rank of *varietas*. According to the ICBN (Greuter et al. 2000), this hybrid taxon cannot be treated as a nothosubspecies, but rather Art H3.3 would require treating it at the nothospecies level. However, it does not behave as a species distinct from *L. camara*, and it is the major representative of the species where it is naturalized, thus, simulating a widespread natural subspecies.

Lantana camara L. subsp. **aculeata** (L.) R.W. Sanders, comb. & stat. nov. (**Fig. 9).**

Basionym: *Lantana aculeata* L., Sp. Pl. 627. 1753. Lectotype designated by Méndez & Cafferty (2001, see App. B).

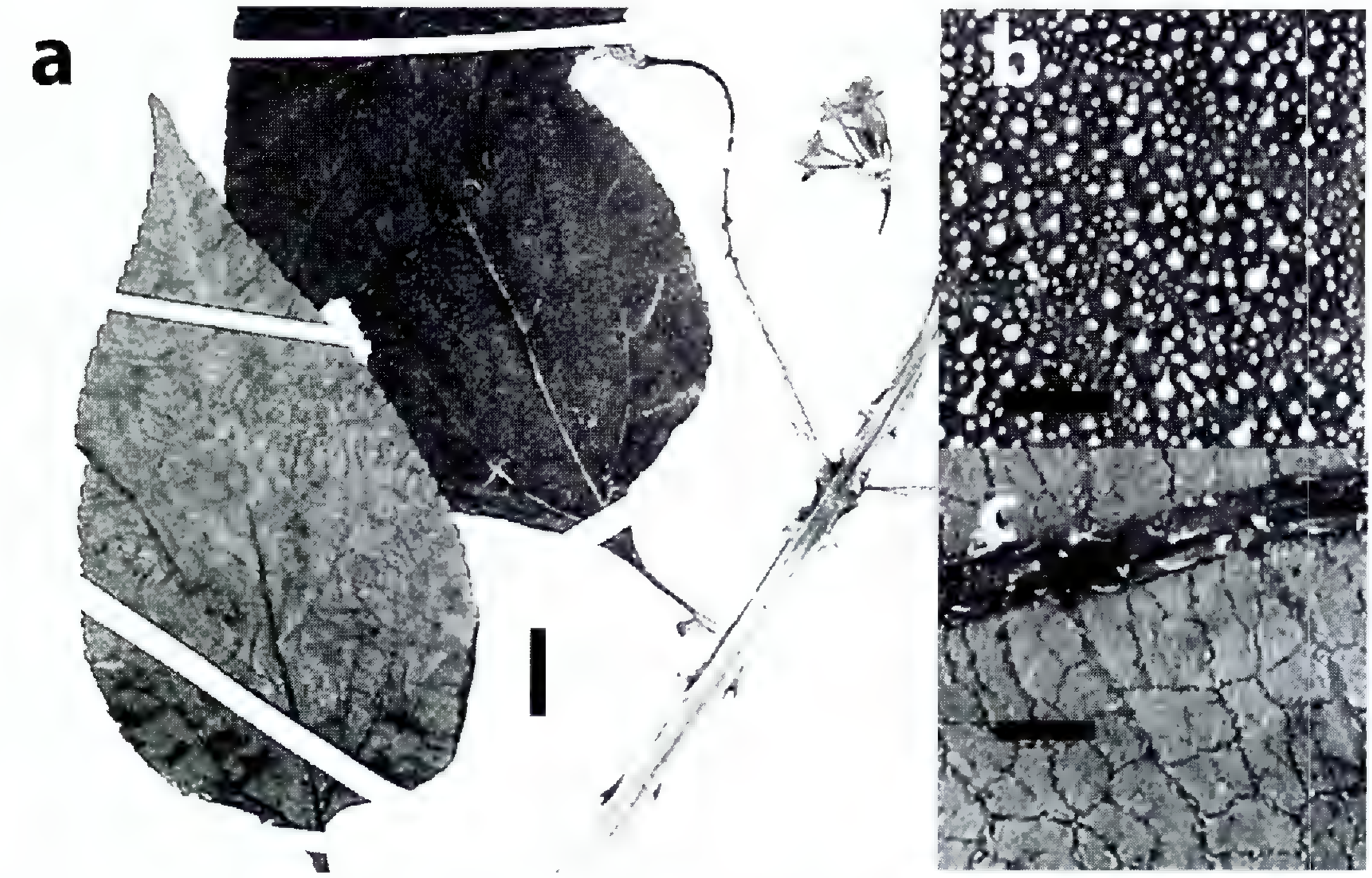


FIG. 7. *Lantana nivea*, epitype (*Siebke s.n.*, C), **a.** stem, representative leaves, inflorescence with peduncle, and inset of inflorescence. **b.** adaxial leaf surface. **c.** abaxial leaf surface. Scale bars: a = 1 cm; b & c = 1 mm.

Likewise, backcrosses of *L. nivea* into the original mixed-color hybrids produced multicolored plants within the range or extending the range of variation of *L. nivea* with respect to other characters. Such plants I consider to be the subspecies combination *L. nivea* subsp. *mutabilis*. It is not treated as a nothotaxon by similar reasoning.

Lantana nivea Vent. subsp. **mutabilis** (W.J. Hook.) R.W. Sanders, comb. & stat. nov. BASIONYM: *Lantana nivea* Vent. var. *mutabilis* W.J. Hook., Bot. Mag. 5: pl. 3110. 1831. LECTOTYPE (here designated): icon in W.J. Hook., Bot. Mag. 5: pl. 3110. 1831.

Lantana nivea subsp. *mutabilis* may have been an important genetic vector for the origin of *L. strigocamara*. Even so, this taxon is not to be identified with *L. strigocamara* regardless of Bailey's (1900) and Moldenke's (1980b) having combined this taxon under *L. camara* and applying it to *L. strigocamara* (Moldenke *in sched.*) (see *L. amethystina* and *L. mutabilis* Lippold ex Otto & A. Dietr, App. B.).

The array of species names, dating from the Linnaean and early post-Linnaean period, that apply to hybrids (App. B, Fig. 12) shows the extent to which horticultural hybridization was complicating the systematics of this group. *Lantana camara* subsp. *aculeata* was hybridized at least with *L. horrida* (producing *L.* ×*mutabilis* C. E. Weigel), with *L. hirsuta* (*L.* ×*mista* L., Fig. 10), and with *L. strigocamara* or some undetermined species or species hybrids from the Strigose Group (*L.* ×*purpurea* Hornem.). *Lantana horrida* was crossed with

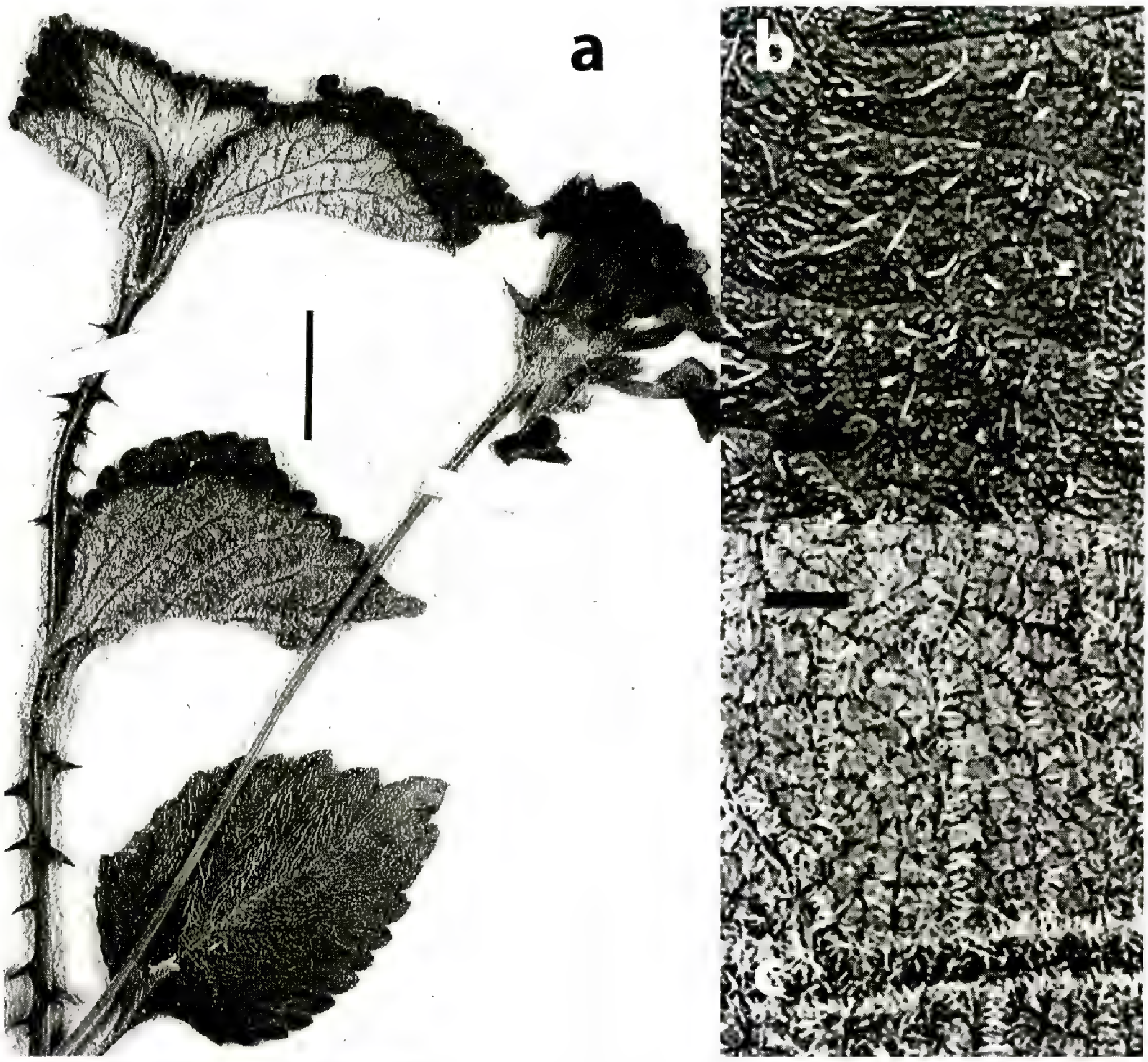


Fig. 8. *Lantana horrida*. **a.** portion of lectotype (*Humboldt & Bonpland 4149*, P-HBK, photograph provided by the Herbier National Paris [P], used with permission). **b–c.** representative specimen (*Laughlin 1535*, LL). **b.** adaxial leaf surface. **c.** abaxial leaf surface. Scale bars: a = 1 cm; b & c = 1 mm.

some of the species or hybrids of the Strigose Group to produce *L.* ×*flava* L. (Fig. 11). This latter hybrid appears to have mixed with backcrosses of *L. nivea* into *L. camara* subsp. *aculeata* (*L.* ×*antidotalis* Schumach. & Thonn.). Furthermore, within the Strigose Group, *L. nivea* was hybridized probably with *L. scabrida* or *L. splendens* to yield *L.* ×*multiflora* Otto & A. Dietr.

At about this time, these various hybrid plants were being introduced and naturalized throughout the tropics, especially as colonists settled in the West Indies, India, South Africa, Indonesia, Australia, and Pacific Islands. In some cases, the hybrids underwent polyploidy resulting in cultivated and escaped plants that grew aggressively and genetically swamped the characters of other cultivated and escaped plants with which they crossed. Thus, over the next two centuries, the diversity of the wild escaped plants was reduced to a few aggres-



FIG. 9. *Lantana camara* subsp. *aculeata*, epitype (BM-SL 98: 143 bottom center). **a.** whole specimen. **b.** adaxial leaf surface. **c.** abaxial leaf surface. Scale bars = 1 mm.

sive cultigens and the recombinant variation expressed in hybrids between cultigens and in those between cultigens and indigenous species.

Apparently having originated along with the other early cultigens, *Lantana strigocamara* became one of the most widespread and aggressive. Clearly it was already escaped and crossing with native *L. urticoides* Hayek of Texas and *L. depressa* of Florida by the 1820s (see *L.*×*rubra* Berland. and *L.*×*floridana* Raf., App. B). *Lantana strigocamara* probably originated as a diploid, because diploid cultivars, usually given names such as 'Dwarf Yellow,' 'Dwarf Pink,' etc., are still available (Sanders 2001). However, post-origin allopolyploidy certainly has contributed to its aggressive growth and success in the wild. In introduced areas, it appears to have steadily increased in numbers, and by the early 1900s it came to dominate the occurrences among pantropical naturalized plants.

Howard (1969) pointed out that during the later half of the nineteenth century, lantanas lost popularity among horticulturalists. Most of the early hybrid cultivars apparently went extinct, except where escaped and naturalized in the absence of competition with *Lantana strigocamara*. However in the 1950s, lantana cultivars, developed primarily from a base of *L. strigocamara*, began to re-

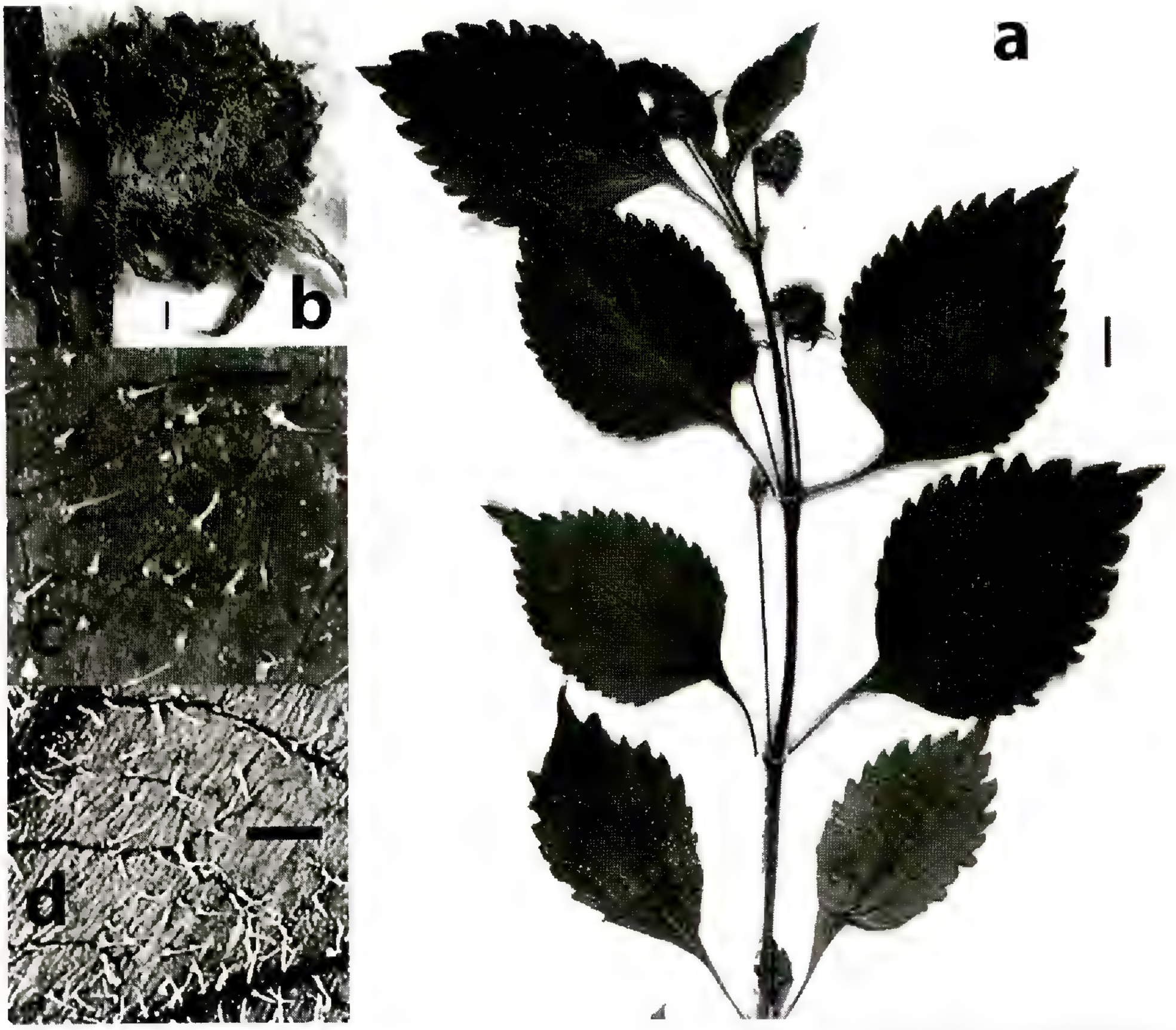


FIG. 10. *Lantana* ×*mista*, epitype (Herb. Sherard 1272, OXF). **a.** whole specimen excluding lowermost 4 cm of stem; note anomalous leaf-shape variation. **b.** inflorescence. **c.** adaxial leaf surface. d. abaxial leaf surface. Scale bars: a = 1 cm; b, c & d = 1 mm.

gain popularity, especially in seasonally dry subtropical areas where they can be used as drought tolerant borders. In particular, Monrovia Nursery in California crossed *L. strigocamara* with the very drought tolerant, persistently blooming *L. depressa* var. *depressa* of Florida to produce the now widely planted Callowiana Hybrids (Sanders 2001).

The Callowiana Hybrids apparently originated after autotetraploidy was induced in *Lantana depressa* var. *depressa*. The resulting tetraploid *L. depressa* would hybridize with tetraploid *L. strigocamara* to produce hybrids with an even balance of characters from both parents. This hybrid was then hybridized with various cultivars of *L. strigocamara* to generate an array of cultivars with a wide variety of floral color combinations, growth habits, and ploidal levels from triploid to hexaploid (Sanders 2001). The Callowiana Hybrids, thus, comprise a spectrum of variation completely connecting *L. strigocamara* and *L. depressa* var. *depressa*. This confusing variation led Moldenke (1975b) to name

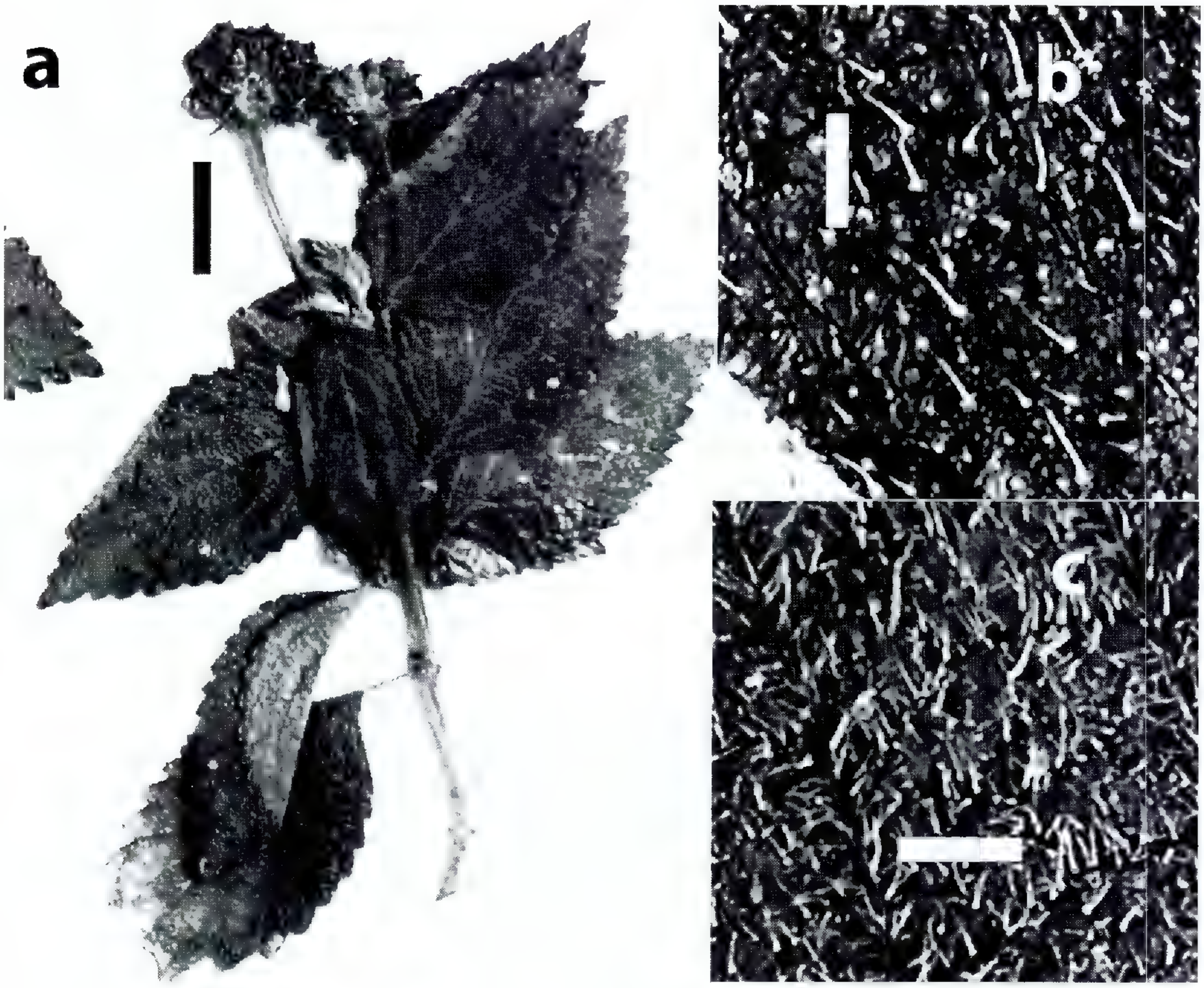


FIG. 11. *Lantana* ×*flava*, epitype (Herb. Sherard 1275, OXF). **a.** inflorescence and representative leaves. **b.** adaxial leaf surface. **c.** abaxial leaf surface. Scale bars: a = 1 cm; b & c = 1 mm.

one of these hybrids, probably Lantana cv. 'Cream Carpet,' as *L. bahamensis* f. *albiflora*.

CONCLUSION AND SUMMARY

The convoluted horticultural and natural history of *Lantana* sect. *Lantana* has resulted in highly complex systematic relationships of both cultivated plants and plants growing in the wild. Initial focus on cultivated forms during the Linnaean period resulted in an early proliferation of names for closely related cultivated plants and hybrids. These names clouded the taxonomy of naturally occurring species as plant exploration penetrated remote areas away from human population centers in colonial tropical America. Horticultural selection developed aggressively growing allopolyploid cultigen species and subspecies that became naturalized, often as pernicious weeds.

Even though *Lantana strigocamara* (i.e., the SCD cultigen), one of the most widespread and aggressive of these cultigens, is characterized predominantly by technical features of the Strigose Group, it became confused with *L. camara*

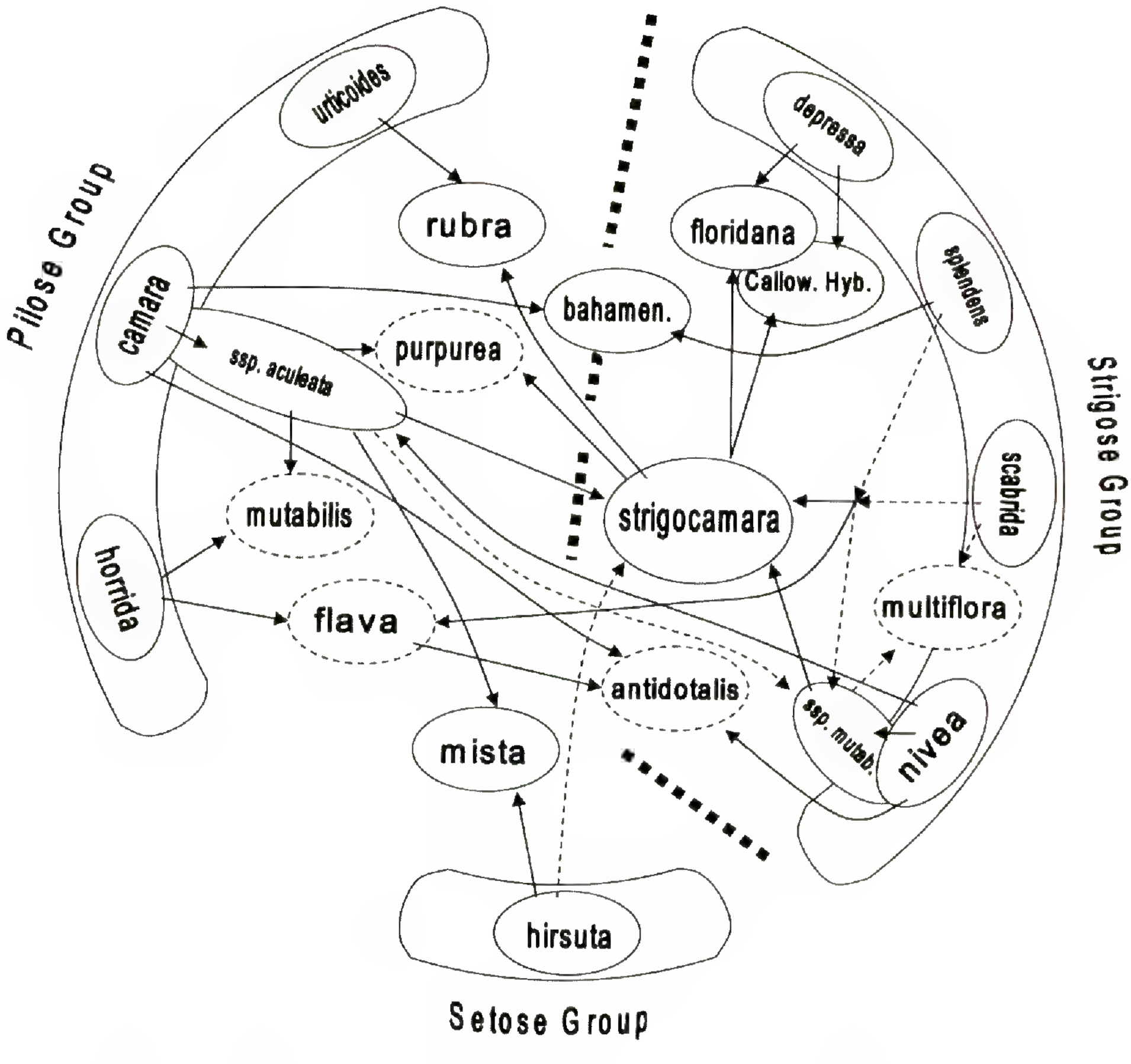


FIG. 12. Diagram showing relationships between natural species and named hybrids. Dashed ovals indicate hybrids that are extinct or rarely seen, either as cultivated plants or as naturalized escapes. Solid arrows indicate known or likely parentage based on admixture or intermediacy of morphological traits. Dashed arrows indicate alternate parentages deduced from characters that occur in several species or from sporadic development of diagnostic parental characters. The heavy dashed line separates the range of variation of the strigose-morph plants on the right from the pilose- and setose-morph plants on the left. The '×' is omitted from hybrid names. For full names see Appendix B.

of the Pilose Group. Otto & Dietrich (1842) applied to one color variant of *Lantana strigocamara* the name *L. mutabilis* Lippold ex Otto & Dietr., but this is an illegitimate later homonym of *L. mutabilis* C. E. Weigel, a name published for the distinct hybrid combination *L. camara* subsp. *aculeata* × *L. horrida* (both of the Pilose Group). Sanders (1987a, b, c, 1989a, b, 2001) and Méndez (2002) both saw the need to treat the widespread SCD cultigen as a distinct species. Unfortunately, Sanders misapplied the name *L. camara* to the SCD cultigen and the name *L. urticifolia* to *L. camara*. Méndez correctly applied the name *L. camara* but misapplied *L.*×*flava* to the cultigen. Thus, the SCD cultigen is newly named and described here as *L. strigocamara*.

As popularity of the original cultivars waned, later horticultural selection used a restricted set of aggressive polyploid hybrids, especially *Lantana strigocamara*, as breeding stock; thus, this species of hybrid origin and its hybrids now strongly dominate the horticultural trade. Furthermore, where it has been introduced into tropical America, it competes or also hybridizes with indigenous taxa to produce a spectrum of variation challenging taxonomic research, which may be resolvable only with cytological and molecular techniques.

APPENDIX A

Use of name *Lantana camara* L. in taxonomic and horticultural literature in which trichomes are sufficiently described, in historical sequence.

Pilose-morph only

Medikus (1775) "folia…minus rugosa, mollioraque foliis Lantanae mistae"

Sprengle (1825) "subtus albido-villosis"

Schauer, (1847) "subtus pallidis paginâ vel reti saltem brevi-villoso subcanescentibus"

Schauer, (1851) diagnosis = "subtus pallidis pagina v. reti saltem brevivilloso subcanescentibus" and description = "Foliorum indumentum variabile, magis pilosum et (subtus imprimis) magis tomentosum, magis minusve densum, tamen semper breve et in facie foliorum scaberrimum, e setulis antrorsis callo insidentibus confectum, neque hirsutum"

Troncoso (1965) "densamente villoso-pubescentes abajo" Note: *Lantana camara* does not naturally occur in Argentina. Thus, this description applies to escaped cultivars or to plants of *Lantana horrida* (incl. *L. tiliifolia*), *L. micrantha*, and *L. riedeliana*, which are native but submerged by Troncoso into *L. camara*.

Pilose- and strigose-morphs both included

Voss (1896) "oberseits scharf, unterseits blasser odor auf der Unterfläche oder ihrem Adernetz kurz-grauweiß-zottig." [inclusion of wide range of hair morphs clear from synonymy, included varieties, and use of "scharf" to modify "zottig."]

Bailey (1900) "pubescent beneath" [inclusion of wide range of hair morphs clear from synonymy and included varieties.]

Standley (1924) "variously pubescent or occasionally glabrate beneath"

Hutchinson & Dalziel (1931) "shortly pubescent below"

Bailey (1951) "pubescent beneath" [inclusion of wide range of hair morphs clear from synonymy and included varieties.]

Leon & Alain (1957) "el envés pubescente" [term equivocal, could be applied to both morphs]

Macbride (1960) "often canescently short-villous beneath" [presumes less pubescent morphs also included]

Gibson (1970) "variously pubescent beneath (densely viscid-tomentose to strigose or rarely glabrate)"

López-Palacios (1977) varying from "glabresentes" to "esparcido-pilosos o estrigulosos en el envés" to "corto-pubescentes por ambas caras"

Nash & Nee (1984) "el envés densamente viscido-tomentoso a estrigoso o hirsuto, raremente glabro"
Huxley (1992) "pubesc. above and beneath" [inclusion of wide range of hair morphs clear from synonymy and included varieties.]
Cullen et al. (2000) "downy or almost hairless underneath"

Strigose-morph only (or also mixed)

Otto & Dietrich (1841) diagnosis = "subtus hirtulis" and description = "oberhalb durch kleine Höckerchen scharf, etwas kurzhaarig, unterhalb *ebenfalls* [emphasis mine] zerstreut kurzhaarig, und etwas heller grün oder beinahe weißlich [glaucous?]" Note: They described *Lantana moritziana*, which is conspecific with true *L. camara*, as "Die Blätter…kurz-weichhaarig, nur wenig scharf und ziemlich weich anzufahlen." Furthermore, their description of *L. camara* is almost identical to theirs for *L. crenulata*, which Schauer (1847) described as "subtus pallidis, pubescenti-scabris."
Pearson (1912) "scabrid-pubescent above and on the veins beneath"
Moldenke (1970a) "short-pubescent, mostly on the venation beneath"
Long & Lakela (1971) "strigose beneath"
Adams (1972) "Lower surface of leaves thinly pubescent or almost glabrous" (as opposed to "with numerous short hairs")
Moldenke (1973b) "usually only sparsely pilosulous or strigillose beneath (mostly only on the venation) with canescent or brownish trichomes, sometimes glabrescent" [as opposed to "densely puberulent or short-pubescent"]
Correll & Correll (1982) "short pubescent, mostly on the venation beneath"
Moldenke & Moldenke (1983) "usually only sparsely pilosulous or strigillose beneath (mostly only on the venation) with canescent or brownish trichomes, sometimes glabrescent"
Jansen-Jacobs (1988) "strongly or sparsely hirsute-strigose below, especially on the veins"
Wagner et al. (1990) "lower surface sparsely short-pilose or strigillose, sometimes glabrate"
Verdcourt (1992) "± pubescent or glabrescent beneath but scabrid on raised venation"
Liogier (1994) "algo pelositas en el envés, a veces glabrescentes"
Pool (2001) "envés con tricomas estrigosos pequeños limitados a los nervios" [My work, as well as López-Palacios (1977) cited.]

APPENDIX B

Typification and history of application of names in *Lantana* sect. *Lantana*. Unless otherwise noted, herbaria given for authors and collectors in TL-2 (Stafleu & Cowan 1976–1988) were consulted for original material. An exhaustive search for isotypes was not attempted. Unless cited otherwise, handwriting comparisons based on Burdet (1979). A name is considered to be misapplied if the cited author or annotator clearly misunderstood the concept of that species and applied it to a species in such a way to exclude the type. A misapplication is inferred for publication of an infraspecific combination in which the infraspecific taxon actually belongs to a second species that excludes the type of the species under which the combination is made. The hybrid formulae for

nothospecies and species of hybrid origin are presumed parentages based on character combinations and intermediacy.

1753—Lantana camara L., Sp. Pl. 627.

LECTOTYPE (Moldenke & Moldenke 1983).—Cult, probably Hort. Uppsala, Herb. Linnaeus 783.4 (LINN!). (Fig. 1)

Name misapplied to:

L. ×*antidotalis* (Verdcourt 1992)
L. ×*flava* (Moldenke 1980b)
L. horrida (Moldenke 1962, 1982c; Méndez 2002)
L. ×*mista* (Bailey 1900; Moldenke 1942)
L. nivea (Bailey 1900; Moldenke 1955, 1980b)
L. scabrida (Moldenke 1940, 1973b; Adams 1971)
L. splendens (Moldenke 1976)
L. strigocamara (Otto & Dietrich 1841; Moldenke 1940, 1949, 1970a, 1973b, *in sched.*; Long & Lakela 1971; Correll & Correll 1982; Sanders 1987a, b, c, 1989a, b, 2001, *in sched.*; Verdcourt 1992; Liogier 1994)

Taxonomic disposition.—*L. camara* (Pilose Group)

Discussion.—Linnaeus' concept of *L. camara* was developed from an array of garden and horticulturally selected plants. His reference in the protologue, in Sp. Pl. (ed. 2) 1763, and in Syst. Nat. (ed. 12) 1767 to synonyms that include the phrases *"floribus miniatus," "flore variegata,"* and *"flore variabile"* indicates that garden hybridization had already introduced genes of at least *L. nivea* into the material he studied. However, the Moldenkes' lectotypification associated the name with an element characteristic of native Jamaican populations that lack the wider genetic variability and have only flowers opening yellow and changing to darker yellow, or at most, to reddish orange. Indeed, *Proctor 18266* (NY!) and *Yuncker 17043* (NY!), native material from Jamaica, are close matches to LINN 783.4.

Otto and Dietrich (1841) appear to have been the first to misapply *L. camara* to *L. strigocamara*. They described *L. camara* as having leaf blades (my translation) "basally somewhat rounded or almost cordate and having surfaces above with small, rough, sharp, somewhat short hairs, and likewise below scattered short-haired." They restricted the application to material of *L. strigocamara* with flowers opening yellow and aging orange (see also *L. crocea* [1804], *L. moritziana* [1841], *L. mutabilis* Lippold ex Otto & A. Dietr. [1842], and *L. variegata* [1842] below).

Sanders (1987c) explicitly excluded the type of *L. camara* by describing the species as having, "Hairs of abaxial laminar surfaces sparse, restricted mostly to midrib, secondary, and tertiary veins, stout, tapering-conical, geniculate toward base with distal 2/3 held parallel to lamina or vein surface."

1753—Lantana aculeata L., Sp. Pl. 627.

LECTOTYPE (Méndez & Cafferty 2001).— icon in Plukenet, Phytographia t. 233, f. 5. 1692.

EPITYPE (here designated).—Herb. Sloan 98:143 bottom center specimen (voucher of Plukenet, Phytographia t. 233, f. 5). BM-SL! (Fig. 9)

Name misapplied to:

L. camara (Medikus 1775; Méndez 2002)
L. camara × *L. strigocamara* (Méndez 2002)
L. horrida (Koch & Fintelmann 1858; Méndez 2002)
L. nivea (Méndez 2002)
L. strigocamara (Méndez 2002)

Taxonomic disposition.—*L. camara* (as *L. camara* subsp. *aculeata*)

Discussion.—To my knowledge, Schauer (1847) was the first author to place *L. aculeata* in synonymy under *L. camara*, which has equal priority, and his choice is followed.

Méndez and Cafferty chose Plukenet's figure as the lectotype. The voucher of the lectotype (i.e., epitype) is more or less within the range of variation of *L. camara* with regard to indument.

Although the abaxial surface hairs are sparser than is typical of Jamaican material, tnis condition is found in occasional native collections elsewhere. Linnaeus apparently developed the concept of *L. aculeata* to accommodate plants that were otherwise like *L. camara* but differed only by the development of prickles. As with *L. camara*, the protologue indicates both plants with yellow flowers changing only to dark yellow and those with flowers opening yellowish changing to red or purplish. In particular, Plukenet's phrase name includes "*floribus miniatis*." Not only the floral color variation (especially the late anthesis purplish pigments from *L. nivea*), but also the presence of prickles and sparse abaxial foliar hairs both point to hybridization influencing the wider variability in *L. aculeata*. Thus, my concept of the taxon is that of an infraspecific rank to account for all the cultivated and escaped plants of hybrid origin (regardless of floral color) falling within or slightly extending the range of variation of *L. camara*.

Méndez described *L. aculeata* as "abaxial surface with hairs relatively abundant, usually on all veins (including areoli), robust, conical, all, most, or at least a significant portion on the midrib, secondary or tertiary veins geniculate toward base and with distal 2/3 held parellel to vein surface, all those that grow on lower veins shorter and erect." To me, this describes hybrids between *L. camara* and *L. strigocamara*. Therefore, his application of *L. aculeata* to *L. camara* × *L. strigocamara* does not conform to the voucher of the lectotype, pointing out the need for epitypification. Furthermore, *L. aculeata* f. *rubella* (Moldenke) I.E. Méndez is to be identified with *L. strigocamara*, *L. aculeata* f. *nivea* (Vent.) I.E. Méndez with *L. nivea*, and *L. aculeata* f. *parvifolia* (Moldenke) I.E. Méndez with *L. camara*.

This taxon apparently was the main vector for infusing *L. camara* genes into the Strigose Group to produce *L. strigocamara*. It is not now widely avai able in the horticultural trade but appears to be rather widely naturalized in the paleotropics, especially Australia.

1767—Lantana mista L., Syst. Nat. ed. 12, 2:417.

LECTOTYPE (Méndez & Cafferty 2001).—icon in Dillenius, Hort. Eltham. t. 56, f. 64. 1732.

EPITYPE (here designated).—Herb. Sherard 1272. (voucher for Dillenius, Hort. Eltham. t. 56, f. 64) OXF! (Fig. 10)

Name misapplied to:

L. hirsuta (Schauer 1847, 1851 t. 42)

L. horrida (Méndez 2002)

Taxonomic disposition.—*L.* ×*mista* (*L. hirsuta* × *L. camara* subsp. *aculeata*)

Discussion.—Reliance on the Dillenius figure led Méndez (2002) to associate this name with the wild species, *L. horrida*, which occurs in the Greater Antilles. However, when the epitype (i.e., voucher of the figure) is examined with reference to critical trichome characters, it is shown to be a hybrid between *L. hirsuta* and *L. camara* subsp. *aculeata*. It is not typical of *L. horrida*.

This hybrid combination is mostly of historical interest, as it is not now widely available in the horticultural trade and may have served as an agent for further hybridization and introduction of wider genetic variation into the cultivated complex.

1768—Lantana urticifolia Mill., Gard. Dict. ed. 8, Lantana 5.

LECTOTYPE (Sanders 1989a).—Mexico. Edo. Veracruz: Veracruz, *Houstoun s.n.*, Herb. Sloane 6:84. (BM-SL [dig. photo!, mounted photos NY!, UC!]).

Name misapplied to:

L. camara (Moldenke *in sched.*; Adams 1971; Sanders 1987b, c, 1989a, b; Liogier 1994)

L. horrida (Adams 1971; Sanders 1987b, 1989a)

Taxonomic disposition.—*L. camara* (see 1753)

Discussion.—Mark Spencer (Linnaean Typif cation Project, pers. comm.) verified that Herb. Sloane 6:84, collected by Houstoun at Veracruz, Mexico, is the only specimen bearing Miller's polynomial and is the only known original material of *L. urticifolia*. Nash & Nee (1984) cited the collection as "type" but questioned its existence at BM. Based on a mounted photograph at UC of the specimen at BM, Sanders (1989a) cited the specimen as "holotype" which is to be corrected to "lectotype."

Because Sanders (papers cited above) had misapplied *L. camara* so as to exclude its type, he applied the name *L. urticifolia* to provide a species name to all members of *L. camara*. In his concept of *L. urticifolia*, he also included the species *L. horrida*, here regarded as distinct.

1775—Lantana flava Medik., Hist. & Commentat. Acad. Elect. Sci. Theod.-Palat. 3. Phys. 225.
Lectotype (here designated).—icon in Dillenius, Hort. Eltham. t. 57, f. 66. 1732 .
Epitype (here designated).—Herb. Sherard 1275 (voucher for Dillenius, Hort. Eltham. t. 57, f. 66). OXF! (Fig. 11)
Name misapplied to:
L. camara (Schauer 1847; Koch & Fintelmann 1858)
L. scabrida (Méndez 2002)
L. strigocamara (Méndez 2002)
Taxonomic disposition.—*L.* ×*flava* (*L. horrida* × *L. spp.* Strigose Group)
Discussion.—There is no indication on the Sherard specimen that Medikus saw it, and his description closely parallels Dillenius'. Because the protologue cites only Dillenius' name in synonymy, the Dillenius plate must be the type.

The protologue clearly describes the lower leaf surface as "pallidiora, tomentoso-pilosa." In bearing the mixture of long and short appressed hairs on the foliar upper surface and mixture of antrorse strigae with softer, filiform hairs on the lower surface, the epitype (i.e., voucher of the lectotype) agrees with the protologue and confirms that the parentage consists of *L. horrida* and one or more species of the Strigose Group. Therefore, it is not clear why Méndez (2002) chose to apply this name to material of *L. strigocamara*. He cited neither the plate nor its voucher.

This hybrid combination is mostly of historical interest, as it is not now widely available in the horticultural trade and may have served for further hybridization and introduction of wider genetic variation into the cultivated complex.

1775—Lantana splendens Medik., Hist. & Commentat. Acad. Elect. Sci. Theod.-Palat. 3. Phys. 226.
Lectotype (here designated).—icon in Dillenius, Hort. Eltham. t. 57, f. 67. 1732.
Epitype (here designated).—Herb. Sherard 1269 (voucher for Dillenius, Hort. Eltham. t. 57, f. 67), left hand stem. OXF! (Fig. 6)
Name misapplied to:
L. strigocamara (Moldenke & Moldenke 1983)
Taxonomic disposition.—*L. splendens* (Strigose Group)
Discussion.—The lectotypification by Moldenke & Moldenke ([*Dillenius s.n.*, OXF] 1983) is rejected as both imprecise and incorrect. The protologue cites as original material only the Dillenius name and plate as a definite synonym and a Plukenet name and plate as a questioned synonym. Not only does Medikus' description closely parallel Dillenius', but the voucher is not annotated by Medikus. Therefore, there is no evidence that Medikus studied the specimen, and the Dillenius plate is chosen as lectotype. Both the protologue and the epitype (i.e., the voucher of the lectotype) match native material from the Bahama Archipelago, the provenance given by Dillenius.

1775—Lantana sanguinea Medik., Hist. & Commentat. Acad. Elect. Sci. Theod.-Palat. 3. Phys. 229.
Type.—Unknown.
Name misapplied to:
L. camara or *L.* ×*mista* (Schauer 1847)
Taxonomic disposition.—*L. camara* subsp. *aculeata* (see 1753) or *L.* ×*mista* (see 1767)
Discussion.—Medikus cited no synonyms, illustrations, or specimens that could serve as type. His own herbarium is unknown. His description of trichomes is scant, making clear application of the name difficult. He did relate it most closely to *L. aculeata* L.; thus, the assumption made here is that it is a color variant of that taxon or *L. mista* L., for which he gave a similar description, except for ultimate color of the corollas.

1776—Lantana mutabilis C. E. Weigel, Physiogr. Sällsk. Hand. 1:46.
LECTOTYPE (here designated).—Cult., Greifsweld Bot. Gard. ("H.Gryph."), *Pyl s.n., Aug. 1774* (JE [dig. photo!]).
Taxonomic disposition.—*L.* ×*mutabilis* (*L. camara* subsp. *aculeata* × *L. horrida*)
Discussion.—The protologue indicates that the material growing in the Greifsweld Botanic Garden was the basis of the new species. The 1774 collection by Pyl is the only original material found at JE and was annotated by Weigel (J. Mueller, JE, pers. comm.). Interestingly, Weigel cited *Camara melissae folio, flore variabili* Dill. (Hort. Eltham. 65, t. 56, f. 65), in synonymy. The voucher of the illustration (Herb. Sherard 1274, OXF!) also is a hybrid between *L. camara* subsp. *aculeata* and *L. horrida*.

1789—Lantana scabrida Sol. in Aiton, Hort. Kew, ed. 1, 2:352.
LECTOTYPE (here designated).—Cult. Royal Bot. Gard. Kew, "Hort. Kew 1777," (*Solander s.n.*?) (BM!). (Fig. 2)
Taxonomic disposition.—*L. scabrida* (Strigose Group)
Discussion.—The specimen at BM apparently is the only original material. It is annotated "Hort Kew 1777" in an unknown hand, possibly Solander's, and "*Lantana scabrida* Ait. Hort. Kew ii 352!" possibly by J. Britton (M. Spencer, BM, pers. comm.). The only material cited in the protologue is "Nat. of the West Indies, Mr. Gilbert Alexander, Introd. 1774."

1789—Lantana melissifolia Sol. in Aiton, Hort. Kew, ed. 1, 2:352. *nom. illeg.* (superfluous)
LECTOTYPE (here designated).—icon in Dillenius, Hort. Eltham. t. 57, f. 66. 1732.
EPITYPE (here designated).—Herb. Sherard 1275 (Voucher for Dillenius, Hort. Eltham. t. 57, f. 66). OXF!
Taxonomic disposition.—*L.* ×*flava* (see 1775)
Discussion.—Solander cited *Lantana flava* Medik. in synonymy and cited the Dillenius plate. Evidence is lacking that he studied the voucher in the Sherard Herbarium.

1796—Lantana mutabilis Salisb., Prodr. Stirp. Chap. Allerton. 107. *nom. illeg.* (later homonym of *L.* ×*mutabilis* C. E. Weigel)
TYPE.—None selected.
Taxonomic disposition.—*L. camara* subsp. *aculeata* (see 1753)
Discussion.—Because this is a later homonym of *L.* ×*mutabilis* C. E. Weigel, it presents no problems. Based on the protologue, Salisbury appears to have named material with heads that change colors from yellow to purple. He cited only *L. camara* Linnaeus in Sp. Pl. (ed. 2) 1763 in synonymy; so, it is not clear whether he was assigning a substitute name or separating the material with multicolored heads as a new species.

1804—Lantana crocea Jacq., Pl. Hort. Schoenbr. 4:t. 473.
LECTOTYPE (here designated).—icon in Jacq., Hort. Schoenb. 4:t. 473.
Name misapplied to:
L. bahamensis (Schauer 1847; Koch & Fintelmann 1858)
L. camara (Otto & Dietrich 1842)
L. scabrida (Schauer 1847; Koch & Fintelmann 1858)
L. splendens (Schauer 1847)
Taxonomic disposition.—*L. camara* (see 1753)
Discussion.—No original material other than the plate has been found. The plate is a good match for many wild collected specimens from Jamaica. These differ from the type of *L. camara* only by details of leaf shape. However, herbarium samples suggests (unpubl. observ.) that, among Jamaican populations, leaf-shape variation is not correlated with geography or ecology.

Because Otto and Dietrich (1841, 1842) applied *L. camara* to *L. strigocamara* (see above), they applied *L. crocea* to *L. camara*, restricting its use to material with heads changing from yellow to orange and stems with prickles (see *L. moritziana*, 1841).

1804—Lantana nivea Vent., Jard. Malmaison t. 8.
LECTOTYPE (Here designated).—icon in Vent., Jard. Malmaison t. 8.

EPITYPE (here designated).—Cult., Paris "ex h. Paris, mis. Siebke," *Siebke s.n.*, C! (Fig. 7)
Taxonomic disposition.—*L. nivea* (Strigose Group)
Discussion.—Ventenant provided a good description, excluding some details of leaf indument. Although the garden at Malmaison received material from gardens in the East Indies, it is clear that the description and plate apply to native material from southeastern Brazil, as noted by Schauer (1847). None of Ventenant's original material cultivated in Paris was located in B-WILLD, C, G, or P (no response from WU). A specimen found in C and cultivated in Paris was annotated as *L. nivea*, but apparently not in Ventenant's hand, indicating it not to be original material. Because subsequent authors have misunderstood this species as evidenced by the several new names described for more recent wild collections of this species, the specimen in C is designated as to support the icon. It clearly matches the protologue and was at Paris about the time of Ventenant such that the annotator should have been familiar with Ventenant's concept.

1815—Lantana purpurea Hornem., Hort. Bot. Hafn. 2:583.
LECTOTYPE (here designated).—Cult. Hort. Reg. Bot. Hafn. "1814" (C!).
Name misapplied to:
L. camara (Schauer 1847; Koch & Fintelmann 1858; Bailey 1900)
Taxonomic disposition.—*L.* ×*purpurea* (*L. camara* subsp. *aculeata* × *L. spp.* Strigose Group)
Discussion.—The lectotype is in a type folder marked as "specimina originalia" (also labeled as "IDC microfiche 111[II-1-2]). The verso is annotated "Lantana purpurea Horne. 1814," presumably in Hornemann's hand, and stamped "Hb. Schum.." A second specimen (IDC microfiche 111[1-7]) is annotated "Lantana purpurea h.h." in a different hand and stamped "Hb. Liebm." Both specimens are characterized by a mixture of erect and geniculate trichomes on the abaxial surfaces. The purplish corollas suggest that a purple-flowered cultivar of *L. camara* subsp. *aculeata* was crossed with a cultivar from The Strigose Group.

1817—Lantana hispida Kunth in HBK., Nov. Gen. Sp. 2:260.
LECTOTYPE (Nash & Nee 1984).—Mexico. Edo. Veracruz: "juxta Xalapam," *Humboldt & Bonpland s.n.* (P-HBK [dig. photo!, Macbride Neg. 39493 F!, BRIT!]).
Name misapplied to:
L. hirsuta (Moldenke 1947, 1973b)
L. hirta Grah., *sp.* sect. *Callioreas* (Schauer 1848; Koch & Fintelmann 1858; Standley 1924; Moldenke 1963, Gibson 1970)
L. velutina Mart. & Gal., *sp.* sect. *Callioreas* (Moldenke 1982c)
Taxonomic disposition.—*L. horrida* (see next)
Discussion.—Schauer's misapplication of the name to *L. hirta* Graham in section *Calleoreas* has resulted in persistent confusion. Furthermore, the epithet is easily confused with *L. hirsuta* M. Martens & Galeotti, a distinct species. Therefore, in combining *L. hispida* with *L. horrida* as conspecific, I choose the latter in accord with ICBN Article 11.5 (Greuter et al. 2000).

1817—Lantana horrida Kunth in HBK., Nov. Gen. Sp. 2:261.
LECTOTYPE (Nash & Nee 1984).—Mexico. Distrito Federal: "monte Chapultepeque juxta urbem Mexici,." *Humboldt & Bonpland 4149* (P-HBK [dig. photo!]). (Fig. 8a)
Name misapplied to:
L. ×*rubra* (Schauer 1847)
L. urticoides (Moldenke 1942, 1961, 1970a, 1978)
L. hirsuta × *L. camara* (Moldenke 1982d)
Taxonomic disposition.—*L. horrida* (Pilose Group)
Discussion.—*Berlandier 2310*, annotated by Berlandier as *Lantana rubra* (*L. urticoides* × *L. strigocamara*), a syntype of *L. horrida* var. *parviflora* Schauer, and the epitype of *L.* ×*rubra* (see below) was mistakenly included in *L. horrida* by Schauer (1847). As a result, Moldenke misapplied the name *L. horrida* to *L. urticoides* until correcting himself (Moldenke 1978).

1827—Lantana antidotalis Schumach. & Thonn. in Schumach., Beskr. Guin. Pl. 276.
LECTOTYPE (Junghans 1962. p. 94, as to collection; here designated as to duplicates).—Ghana, *Thonning 125* (C [IDC microfiche ident. no. 64 [3-4]]!; SOLECTOTYPE: C[IDC. no. 64 [5-6]]!).
Taxonomic disposition.—L. ×antidotalis (*L. nivea* × *L. camara* × *L. ×flava*?)
Discussion. —The duplicate most in accord with the protologue (leaf blades 2-3 inches long) is chosen as the lectotype. Though given the same collection number, these two specimens may actually represent two different populations as judged from slight morphological differences. Assigning hybrid status to this naturalized plant is based on the variable leaf shape and size (narrowly ovate-oblong or narrowly triangular; length 1.7 to 2.7 × width), subsetiform trichomes on the upper and lower leaf surfaces, and the mixture of erect and geniculate hairs on the lower leaf surfaces. The parentage probably includes *L. nivea* or *L. splendens* from the Strigose Group and *L. camara* and *L. ×flava* from the Pilose Group.

1829—Lantana albopurpurea Desf., Tabl. École Bot., ed 3. 393.
LECTOTYPE (here designated).—Cult. Hort. Paris., "H. p." labeled "Herbarium Webbiana ex Herb. Desfontaines" (FI [dig. photo!]).
Taxonomic disposition.—L. ×mista (see 1767)
Discussion.—The specimen at FI is clearly original material, as the annotation is in Desfontaines' hand (C. Nepi, pers. comm.). None other is known to me. The leaf indument suggests this specimen has the same parentage as does *L. ×mista*.

1829—Lantana suaveolens Desf., Tabl. École Bot., ed 3. 393. *nom. illeg.* (*non L. suaveolens* Spreng. = *L. angustifolia* Mill.)
TYPE.—Not investigated.
Taxonomic disposition.—probably *L. camara* or its hybrid (see 1753)
Discussion.—The description of prickly stems, ovate leaves, lanuginose bracts, and yellow flowers suggests this is an element of *L. camara*.

1832—Lantana rubra Berland. in Terán & Berland., Mem. Comis. Limites 15.
LECTOTYPE (here designated).—icon in Berlandier in Ohlendorf et al., transl. Journey Mex., t. 5 (top, facing p. 410). 1980.
EPITYPE (here designated).—*Berlandier 2310=880*, Mexico. Tamaulipas: Matamoros, GH! (ISOEPITYPE: NY!, none found at G under *L. rubra*).
Taxonomic disposition.—L. ×rubra (L. urticoides × *L. strigocamara)*
Discussion.—The only original material known to me includes the recently published plate, which Berlandier either executed or supervised, and three sheets (*Berlandier 2114=697* [GH!], *2310=880* [GH!, NY!]), which consist of hybrids. Although the protologue suggests *L. urticoides* (see 1906 below), the only native species in the region of the eastern Texas-Mexico boundary, all the original material lacks the rotund, large-toothed leaf blades and persistant fruiting bracts, characteristic of *L. urticoides*. Instead, they are intermediate between *L. urticoides* and *L. strigocamara*, which obviously had become well enough established by the late 1820s to produce spontaneous hybrids with *L. urticoides*. If any of the hybrid specimens were chosen as lectotype and other original material that actually belongs to *L. urticoides* should be found, such a lectotypification could be easily overturned. However, stability of the application of *L. rubra* and retention of *L. urticoides* as the correct name of the wild species is best served by accepting the plate as lectotype.

Of the two Berlandier gatnerings know to me, *2114–697* is more typical of the hybrids, especially in the hoary young stems with spreading subsetiform hairs to 1.5 mm long. *Berlandier 2310=880* has larger teeth and subpersistent bracts more like the *L. urticoides* parent, but the indument shows it to be a hybrid. It is chosen as epitype because it is annotated "*Lantana rubra* B," apparently in Berlandier's hand, is a syntype of *L. urticoides* var. *parvifolia* Schauer, and is represented by duplicates in major herbaria.

This hybrid combination is the typical cultivated plant in Texas and the Gulf Coast Plain of the Southeastern United States. It may have been propagated for the trade due to the cold hardiness arising from the Texas parent, *L. urticoides*.

Index Kewensis (Jackson 1895) cites "*Lantana rubra* Perr.," but this is a mistake as Perrottet (1825) actually referred to *Latania rubra* Jacq. (Arecaceae), the next entry in his list after *Lantana*.

1832—Lantana tiliifolia Cham., Linnaea 7:122.

LECTOTYPE (Santos Silva 2001).—Brazil: Bahia. *Sieber s.n.* (B-WILLD 11502 [dig. photo! Berlin Dahlem. 2005]).

Name misapplied to:

L. strigocamara or its hybrids (Moldenke *in sched*)

Taxonomic disposition.—*L. horrida* (see 1817)

Discussion.—The protologue lists three syntypes—the Sieber collection from Bahia, Brazil, Sellow collections ("southern Brazil…copious numbers from many locations and times," BR [dig. photo!]; NY!, fragment NY!), and *Lhotsky s.n* (n.v.). I disagree with the lectotypification by Santos Silva (2001). In the digital photograph of B-WILLD 11502 provided by B, the specimen appears to have mostly glandular hairs on the stems and petioles. The Sellow specimen at BR bears mostly non-glandular hairs. Chamisso's diagnosis mentions only "ramis…hirtis," although his description (my translation) indicates that the "upper stems have glandular hairs often but not always mixed in." Later, Poeppig segregated the strongly glandular plants as *L. glutinosa* (see 1842 below). Modern usage follows Poeppig in restricting *L. tiliifolia* to the non- or weakly glandular specimens. However, because I treat both *L. tiliifolia* and *L. glutinosa* as synonyms of *L. horrida*, further research is needed to determine whether a proposal to conserve a different type is needed.

1832—Lantana floridana Raf., Atl. J. 148.

TYPE.—Not found in DWC, FI, G, NY, P, P-DU, PH, PI, WIS, or WS; no response from LE, NAP, or W.

Taxonomic disposition.—*L.* ×*floridana* (*L. depressa* × *L. strigocamara*)

Discussion.—The only native wild taxon of the upper Atlantic coast of Florida is *L. depressa* var. *floridana* (Moldenke) R.W. Sanders (see 1905, below). However, the protologue describes the flowers as "versicolor, yellow, orange, red, crimson on same shrub." As discussed in Sanders (1987a), none of the varieties of *L. depressa* is characterized by the orange or red floral pigments. However, this does characterize hybrids between *L. depressa* and *L. strigocamara*, (the latter in Sanders 1987a as *L.* camara). In light of the hybridization between introduced *L. strigocamara* and native *L. urticoides* in Texas in the 1820s (see *L. rubra* 1832 above), *L. strigocamara* was likely also naturalized in Florida by that time, and Rafinesque's description refers to hybrids.

1838—Lantana antillana Raf., Sylva Tellur. 82.

Type.—Not found in DWC, FI, G, NY, P, P-DU, PH, PI, WIS, or WS; no response from LE, NAP, or W.

Taxonomic disposition.—*L. horrida* (see 1817) or *L. camara* (see 1753)

Discussion.—Rafinesque noted this to be *Lantana camara* of authors and an Antillean shrub, which he saw living. He also noted that it differs from *L. floridana* primarily by the stem and leaves hirsute and the bracts ovate-lanceolate and concave. Neither of these characters appears to be consistent with this being an element of *L. strigocamara*.

1838—Lantana rosea Raf., Sylva Tellur. 83.

TYPE.—Not found in DWC, FI, G, NY, P, P-DU, PH, PI, WIS, or WS; no response from LE, NAP, or W.

Taxonomic disposition.—probably *L. reticulata* Pers. or *L. involucrata* L. (. Sect. *Callioreas*)

Discussion.—Even though Rafinesque placed this species in his subgenus Camara Raf., his subgenera are neither well demarcated nor consistent. He included *L. camara* L. in subgenus *Camara* Raf. and the conspecific *L. aculeata* L. in subgenus *Periana* Raf. (along with *L. involucrata*). *Lantana rosea* is described as a native Antillean plant with small roundish (but apically and basally acute) leaves, rounded cinerous stems, and short, ovate bracts, and rose-pink corollas, all of which appear to place it in sect. *Callioreas*.

1838—Lantana incarnata Raf., Sylva Tellur. 83.
TYPE.—Not found in DWC, FI, G, NY, P, P-DU, PH, PI, WIS, or WS; no response from LE, NAP, or W.
Taxonomic disposition.—probably *L. nivea* subsp. *mutabilis* (W.J. Hook.) R.W. Sanders (see 1804 and text, *L. amethystina* 1841)
Discussion.—By 'incarnate,' Rafinesque presumably meant that the heads are flesh-colored in bud, the corollas open cream and turn light or fleshy pink. This is consistent with some populations of *L. strigocamara*. However, the ovate-oblong leaf blades acuminate at both apex and base rule out *L. strigocamara*. The floral color, leaf shape, and long, linear-lanceolate bracts are all consistent with *L. nivea* subsp. *mutabilis*.

1839—Lantana coccinea G. Don, Hort. Brit., ed. 3. 245. *nom. nud.*
TYPE.—Unknown.
Taxonomic disposition.—*L. camara* subsp. *aculeata*?

1841—Lantana crenulata Otto & A. Dietr., Allg. Gartenzeitung 9:363.
TYPE.—Unknown (no original material known; if herbarium specimen from material cultivated in. Hort. Berlin [*Otto s.n.*,?] existed in B, now destroyed; Shauer [1847] indicated seeing a live specimen in Hort. Berlin).
Name misapplied to:
L. splendens (Schauer 1847)
Taxonomic disposition.—*L.* ×*antidotalis* (see 1827) or *L. scabrida* (see 1789)
Discussion.—The protologue cites no original material, but the description strongly suggests *L. scabrida* or related species or hybrids in the Strigose Group. Identity with *L. strigocamara* is excluded because the leaves are described as pointed on both ends.

1841—Lantana moritziana Otto & A. Dietr., Allg. Gartenzeitung 9:369.
LECTOTYPE (Schauer 1857, as to gathering; here designated, as to specimen).—Venezuela. Caracas, *Moritz 163* (G [dig. photo!]; ISOLECTOTYPE: G [lacking inflor., dig. photo!]).
Name misapplied to:
L. camara (Otto & Dietrich, 1841, 1842)
Taxonomic disposition.—*L. camara* (see 1753)
Discussion.—The protologue indicates nativity only by "Habitat in Caracas" without specifically citing the Moritz specimen. In his treatment, Schauer (1847) cited only *Moritz 163* from Caracas, Venezuela, but stated that he saw cultivated and wild-collected herbarium specimens at B. The only duplicates of *Moritz 163* known to me are at G. The one chosen as lectotype bears two annotation labels besides the collection label, all apparently in Schauer's hand. The duplicate at G lacks infloresences, is not annotated by Schauer, but is annotated by Moldenke as "Isotype." Macbride photographed material at B (neg. no. 17478, destroyed [photo F!, BRIT!, GH!]), which he may have thought was type material. The specimen is not signed by either Otto & Dietrich or Schauer, and it bears the date "1844." Therefore it cannot be considered a type, even though López-Palacios (1977) cited it as such.

Because Otto and Dietrich (1841, 1842) misapplied *L. camara* to *L. strigocamara*, they applied *L. moritziana* to plants of *L. camara* with no prickles and flower heads changing from yellow to orange.

1841—Lantana multiflora Otto & A. Dietr., Allg. Gartenzeitung 9:370.
LECTOTYPE (here designated).—Cult. Hort. Berlin, *Otto s.n.* (B, destroyed [Macbride Neg. 17379 F!, BRIT!]).
Taxonomic disposition.—*L.* ×*multiflora* (probably *L. nivea* × *L. scabrida* or *L. splendens)*
Discussion.—Otto and Dietrich cited no specimen, but the destroyed specimen photographed by Macbride appears to have been the only original material. In general, the protologue suggests *L. nivea*; although, the more distinct scabrosity of the leaves suggest *L. scabrida* or *L. splendens*. The floral color, described further in Otto and Dietrich (1842) as lilac (in bud?) changing to yellow, clearly implicates genes of both *L. nivea* and yellow-flowered species of the Strigose Group.

1841—Lantana amethystina Otto & A. Dietr., Allg. Gartenzeitung 9:370.
TYPE.—Unknown (no original material known; if herbarium specimen from material cultivated in. Hort. Berlin [*Otto s.n.*,?] existed in B, now destroyed).
Taxonomic disposition.—*L. nivea* (as *L. nivea* subsp. *mutabilis*, see 1804 and text)
Discussion.—Otto and Dietrich (1842) indicated that this is a replacement name for *L. nivea* var. *mutabilis* W.J. Hooker. Apparently, Otto and Dietrich were not aware of *L. mutabilis* C.E. Weigel and *L. mutabilis* Salisb. but did consider that Lippold had named *L. mutabilis* Lippold ex Otto & A. Dietr. for a distinct species such that the Hooker varietal epithet was unavailable at the rank of species (see next entry).

1842—Lantana mutabilis Lippold ex Otto & A. Dietr., Allg. Gartenzeitung 10:314. *nom. illeg.* (later homonym of *Lantana* ×*mutabilis* C. E. Weigel)
TYPE.—Unknown (no original material known; if herbarium specimen from material cultivated in. Hort. Berlin [*Otto s.n.*,?] existed in B, now destroyed; no material of Lippold found at RB [R. Campostrini F., pers. comm.]).
Taxonomic disposition.—*L. strigocamara* (see 2006 and text) or *L. strigocamara* × *L. camara* subsp. *aculeata*
Discussion.—As noted under *L. camara*, Otto and Dietrich (1841) appear to have applied the name *L. camara* to the phenotypes of *L. strigocamara* having floral heads changing from yellow to orange. However, material of *L. strigocamara* with purplish and yellowish pigments occuring together they apparently described under *L. mutabilis* Lippold ex Otto & A. Dietr. As a later homonym, this name is not available for *L. strigocamara*.

1842—Lantana variegata Otto & A. Dietr., Allg. Gartenzeitung 10:314.
TYPE.—Unknown (no original material known; if herbarium specimen from material cultivated in. Hort. Berlin [*Otto s.n.*,?] existed in B, now destroyed).
Taxonomic disposition.—*L. camara* subsp. *aculeata* or *L. camara* subsp. *aculeata* × *L. spp.* Strigose Group
Discussion.—No holotype or syntypes are cited; however, the protologue suggests cultivated material in the range of *L. camara* subsp. *aculeata* (see 1753).

1842—Lantana glutinosa Poepp. in Otto & A. Dietr., Allg. Gartenzeitung 10:315.
LECTOTYPE (López-Palacios 1977, as to gathering; here designated as to specimen).—Peru, *Poeppig 1375* (G-DC [dig. photo!]; duplicate, B?, destroyed [Macbride Neg. 34340 F!, BRIT!]; ISOLECTOTYPE: GH!).
Taxonomic disposition.—*L. horrida* (see 1817)
Discussion.—Other than "Habitat in Peruvia," no material is cited and lectotypification is required. The Macbride photograpn (Neg. 34340) is presumed to be of a specimen at B, since destroyed, although no herbarium identification is visible in the image. If this be true, it would have been the preferred lectotype.

1842—Lantana asperata Hort. ex Vis., Orto Bot. Padova 142. *nom. nud.*
TYPE.—Unknown.
Taxonomic disposition.—*L. nivea?* (see 1804)
Discussion.—Visiani merely listed the species as having been grown under this name at Hort. Parisiense, without intending to publish it as his own. He also stated, "Non pare diversa della *L. nivea* Vent."

1843—Lantana bartramii Baldwin, Reliq. Baldw. 247.
TYPE.—Not designated.
Taxonomic disposition.—*L.* ×*floridana?* (see 1832)
Discussion.—The protologue cites no material. In a search of DWC, LASCA, MANCH, NY, P-DU, PH, WECO and WLU, only two historical specimens were located. At NY originally in the Torrey Herbarium (T. Zanoni, pers. comm.) is a specimen (!) labeled "grown in Louis Lecontes' Garden in Georgia" without collector or date and annotated as the "*Lantana camara* [var.] *bartramii*, cultivated in

Florida by Dr. Baldwin."This specimen may or may not have been seen by Baldwin. At PH, there is a sheet (dig. photo!) from the Muhlenberg Herbarium that has mounted on it several fragmentary specimens from different collectors. One such fragment is labeled,"1482 Lantana Hardy native"and presumably was collected by Baldwin. Further research is needed to determine if this specimen is original material. Both specimens are elements of *L. depressa* Small var. *floridana* (Moldenke) R.W. Sanders (see 1905).

Baldwin's protologue refers to plants along the Florida seacoast as being the same that Bartram described, without mentioning cultivated material. Bartram traveled only in the geographic range of var. *floridana*. Further, Baldwin describes the species as attaining the height of six feet. Material of *L. depressa* var. *floridana* that I have seen reaches three feet but not six. This, therefore, suggests Baldwin was describing the same hybrid that Rafinesque did under the name *Lantana* ×*floridana*.

1844—Lantana hirsuta M. Martens & Galeotti, Bull. Acad. Roy. Sci. Bruxelles 11:326.

HOLOTYPE.—Mexico. Edo. Veracruz: Jalapa, Mirador, 1840, *Gallioti 749* (BR [dig. photo!]; ISOTYPE: G [dig. photo!]).

Taxonomic disposition.—L. hirsuta (Setose Group)

1846—Camara vulgaris Benth., Bot. Voy. Sulphur 154.

LECTOTYPE (here designated).—Herb. Linnaeus 783.4 (LINN!).

Taxonomic disposition.—L. camara (see 1753)

Discussion.—This was a replacement name for *Lantana camara* when placed in *Camara* Adans. However, the correct name in *Camara.* is *C. aculeata* (L.) Kuntze (Rev. Gen. Plant. 2:503. 1891.)

1847—Lantana armata Schauer, Linnaea 20:480.

LECTOTYPE (here designated, cited as"isotype"by López-Palacios 1977).—Venezuela."ad Caracas,"*Moritz 292* (BM, n.v.; HOLOTYPE now destroyed: B [Macbride Neg. 17463 F!, GH!]).

Name misapplied to:

L. camara (Moldenke 1972a)

Taxonomic disposition.—L. hirsuta (see 1844)

1847—Lantana polyacantha Schauer in DC., Prodr. 11:597.

HOLOTYPE.—Mexico, *Schiede s.n.* (B, destroyed, Macbride Neg. 17481 [F!]).

Taxonomic disposition.—L. horrida (see 1817)

1847—Lantana cujabensis Schauer in DC., Prodr. 11:599.

LECTOTYPE (Santos Silva 2001).—Brazil. Matto Grosso, *Manso s.n.*, Mart. Fl. Bras. 1026 (M, n.v.; ISOLECTOTYPES: BM, BR (2) [dig. photos!], G-DC [dig. photo!, Macbride Neg. 7873 F!, BRIT!], G [dig. photo!, Macbride Neg. 24632 F!, BRIT!], K, NY!).

Name misapplied to:

L. nivea (Moldenke 1981a)

L. viscosa (Moldenke 1984)

Taxonomic disposition.—L. cujabensis (Strigose Group)

Discussion.—The are two paratypes known to me. One is *Poeppig 1485* (Peru) at G. It apparently is annotated by Schauer (without his "!"). He cited *Poeppig 1405* which is probably a typographical error for"1485."The other is *Martius s.n.* (Brazil. Rio Negro) at M (n.v.).

1847—Lantana robusta Schauer in DC., Prodr. 11:601.

LECTOTYPE (Santos Silva 2001). Brazil. Rio de Janeiro:"ad Padre do Correia," 1821, *Pohl 40 5955* (W, n.v.).

Taxonomic disposition.—L. robusta (Setose group)

Discussion.—There is a Macbride photograph (Neg. 17485 [F!, BRIT!, GH!, LL!, NY!]) of *Pohl 182* at B, now destroyed, that has been distributed as a photograph of a type. The specimen in the photograph should be disregarded as original material. This specimen neither appears to be annotated by Schauer nor bears sufficient inflorescence material to match the protologue. Furthermore, the paratype, *Raben 509* (NY [fragment]! and BR [photo at LL!]), and *Pohl 182* are not the same species.

Pohl 182 may belong to *L. horrida* or *L. horrida* × *L. robusta*.

1847—Lantana riedeliana Schauer in DC., Prodr. 11:601.
Holotype.—Brazil, *Riedel s.n.* (LE, n.v.).
Name misapplied to:
L. sp. sect. *Callioreas* (Moldenke 1970b)
Taxonomic disposition.—*L. riedeliana* or *L. robusta?*
Discussion.—The only original material cited is a unicate at LE, which did not respond to inquiries. There is a photograph in LL (perhaps by Moldenke) of *Glazier 1651* that is annotated as *L. riedeliana* by Moldenke, as well as someone other than Schauer. This specimen appears to fit the description of *L. riedeliana* and suggests that *L. riedeliana* is conspecific with *L. robusta*, being a glabrescent, more narrow-leaved variant.

1847—Lantana pohliana Schauer in DC., Prodr. 11:601.
Type (Lectotype not designated).—Brazil, *Pohl s.n.* (W?, n.v.; duplicate: B, destroyed [Macbride Neg. 17480 F!, BRIT!, GH!]).
Taxonomic disposition.—*L. pohliana* or *L. viscosa?* (Setose Group?)
Discussion.—Schauer cited no collection number or herbarium. Pohl material should be at W, but no response to inquires there was received. Further investigation is needed.

1847—Lantana viscosa Pohl ex Schauer in DC., Prodr. 11:601.
Lectotype (Santos Silva 2001).—Brazil. Goiás: "Ad Conceição, prope Trahiras," *Pohl 1876 & 2680* "D. n° 181." (left-hand specimen) (W, n.v.; solectotype: B, destroyed [Macbride Neg. 17492 F!, BRIT!])
Taxonomic disposition.—*L. viscosa* (Setose Group)

1847—Lantana multicolor Lem., Fl. Serres Jard. Eur. 3:239.
Type.—Unknown.
Name misapplied to:
L. camara subsp. *aculeata* or its hybrid (Koch & Fintelmann 1858)
Taxonomic disposition.—*L. camara* subsp. *aculeata*, *L.* ×*mista*, or *L. sp.* sect. *Callioreas?*
Discussion.—Seeds of this were sent to Brussels from Mexico, possibly of cultivated origin. Lemaire distinguished it from other cultivated lantanas by its unusually large leaves and by the rose and crimson flowering heads. Although Koch & Fintelmann (1858) recognized the species, they indicated that it may be a form of *L. camara* or *L.* ×*mista*. However, the protologue also describes the heads as involucrate with four large bracts and with the floral bracts cordate-rotund. These characters would place the plants in section *Callioreas*.

1857—Lantana hybrida Neubert, Deutsch. Mag. Garten- Blumenk. 10:98. *nom. illeg. (nom. subnud.)*
Lectotype (here designated).—icon in Neubert, Deutsch. Gart. Mag. 10:t. facing p. 112.
Name misapplied to:
L. camara subsp. *aculeata* or *L. strigocamara* (Everett 1980)
Taxonomic disposition.—*L.* ×*flava* (see 1775) or *L.* ×*mista* (see 1767)
Discussion.—No specimens were found at HOH or STU to serve as lectotype or epitype. The description is very brief, indicating only the color of the flower heads. The plate shows nothing distinctive except for spreading hairs on the twigs, petioles, and peduncles, suggesting that the plants may be elements of *L.* ×*flava* or *L.* ×*mista*.

1858—Lantana formosa K. Koch & Fintelmann, Wochenschr. Gärtnerei Pflanzenk. 1:322. *nom. illeg., pro syn. sub L. crocea*
Type.—Unknown.
Taxonomic disposition.—*L. camara* (see 1753)

1863—Lantana triplinervia Turcz., Bull. Soc. Imp. Naturalistes Moscou 36:205.
Holotype.—Java, *Goering 225* (KW?, n.v.).

Name misapplied to:

L. nivea (Moldenke 1974, 1977)

L. nivea × *L. spp.* Pilose Group (Moldenke 1974, *in sched.*; Sanders *in sched.*)

Taxonomic disposition.—*L. nivea* (see 1804)

Discussion.—Turczaninow described material that was cultivated or escaped from cultivation. The protologue strongly suggests *L. nivea* by the leaves long petiolate, ovate-lanceolate, triplinerved, apically acuminate, and minutely scabrous on the veins below.

1863—Lantana bahiensis Turcz., Bull. Soc. Imp. Naturalistes Moscou 36:206.

Holotype.—Brazil. Bahia, *Salzmann s.n.* (KW?, n.v.).

Name misapplied to:

L. nivea × *L. spp.* Setose Group (Moldenke *in sched.*)

Taxonomic disposition.—*L. sp.* sect. *Callioreas*

Discussion.—The protologue classifies this species in section *Callioreas*, which is corroborated by the description of bracts ovate, briefly acuminate, and 5-nerved.

1904—Lantana micrantha Briq., Annuaire Conserv. Jard. Bot. Gèneve 7-8:299.

Holotype.—Paraguay. Asunción, *Balansa 1039* (G).

Name misapplied to:

L. horrida (Moldenke 1948, 1975d)

L. sp. sect. Callioreas (Moldenke 1981c)

Taxonomic disposition.—*L. micrantha* (Pilose Group)

1905—Lantana depressa Small, Bull. New York Bot. Gard. 3:436.

Holotype.—USA. Florida: Dade Co.: pinelands between Coconut Grove and Cutler, *Small & Carter 747* (NY; isotype: F!).

Taxonomic disposition.—*L. depressa* (Strigose Group)

Discussion.—See Sanders (1987a)

1905—Lantana bahamensis Britton, Bull. New York Bot. Gard. 3:450.

Holotype.—Bahamas. New Providence: Ft. Montague, *Britton & Brace 174* (NY!; isotypes: F!, US!).

Name misapplied to:

L. camara (Moldenke 1975a; Correll & Correll 1982 (pro parte))

L. depressa (Moldenke 1975c)

L. depressa × *L. strigocamara* Callowiana Hybrids (Moldenke, 1975b)

L. splendens (Moldenke *in sched.*; Correll & Correll 1982 (pro parte); Sanders *in sched.*)

Taxonomic disposition.—*L. bahamensis* (sp. hybrid origin between *L. splendens and L. camara*)

Discussion.—Apparently *Lantana camara*, occurring in the southern Bahamas, began to hybridize introgressively into *L. splendens*, centered in the central Bahamas, shortly after settlement by Europeans. As a result, the native plants in the Bahamas are variable. The type of *L. bahamensis* shows the nitid surface and scattered geniculate hairs on the leaf undersurface venation typical of *L. splendens*, as well as the soft, erect hairs persisting along the undersurface veins, apparently expressing genes of *L. camara*. The bracts vary from oblong-lanceolate as in *L. splendens* to obovate-elliptic as in *L. camara*.

1905—Lantana ovatifolia Britton, Bull. New York Bot. Gard. 4:123.

Holotype.—Bahamas. Grand Bahama: Eight Mile Rocks, *Britton & Millspaugh 2450* (NY!; isotype: F!).

Name misapplied to:

L. depressa (Long 1970; Long & Lakela 1971; Moldenke 1982)

L. strigocamara × *L. depressa* (Long & Lakela 1971) = *L.* ×*floridana* Raf.

Taxonomic disposition.—*L. ovatifolia* (Strigose Group)

Discussion.—See Sanders 1987a.

1906—Lantana glandulosissima Hayek, Repert. Spec. Nov. Regni Veg. 2:161.

HOLOTYPE.—Mexico. Jalisco: Tequila, *Pringle 4431* (W, n.v.; ISOTYPES: BR, F!, MO!, NY!).
Name misapplied to:
L. horrida (Méndez 2002)
Taxonomic disposition.—L. camara (see 1753)

1906—Lantana cummingiana Hayek, Repert.Spec. Nov. Regni Veg. 2:161.
HOLOTYPE.—Chile. *Cumming 1065* (W, n.v.)
Taxonomic disposition.—L. horrida (see 1817) *or L. hirsuta* (see 1844)

1906—Lantana urticoides Hayek, Repert.Spec. Nov. Regni Veg. 2:162.
TYPE.—Not selected, to be lectotypified in a subsequent paper. (Syntypes: USA: Texas. Lindheimer Exsic. No. 503, which includes two different Lindheimer numbered collections, F!, GH!, MO!, UC!, W, n.v.; Texas: Comal Co. *Matthes 19*, W, n.v.).
Name misapplied to:
L. horrida (Moldenke 1981b)
Taxonomic disposition.—L. urticoides (Setose Group)
Discussion.—See *L. rubra* 1832 above.

1907—Lantana foetida Rusby, Bull. NewYork Bot. Gard. 4:431.
HOLOTYPE.—Bolivia, *Bang 2034=469* (NY [n.v., dig. photo not available]; ISOTYPES: US!, GH!).
Taxonomic disposition.—L. horrida (see 1817)

1909—Lantana weberbaueri Hayek in Urb., Bot. Jahrb. Syst. 42:166.
HOLOTYPE.—Peru. Junin: Tarma: Palca, *Weberbauer 2017* (GB?, n.v., W?, n.v., or B? [destroyed, Macbride Neg. 17493, LL!]).
Taxonomic disposition.—L. weberbaueri or *L. viscosa* (see 1847) or its hybrid? (Setose group)
Discussion.—This is a rare, poorly known species. Hayek's opinion was that it is near *L. viscosa* and *L. robusta* in the Setose Group of section *Lantana*.

1910—Lantana arida Britton, Bull. Torrey Bot. Club 37:357.
HOLOTYPE.—Jamaica, Fort Henderson, *Britton & Hollick 1824* (NY!).
Name misapplied to:
L. camara (Moldenke, 1982a)
L. horrida (Moldenke, 1982a; Méndez, 2002)
Taxonomic disposition.—L. horrida (see 1817)
Discussion.—This is a small-leaved variant of Antillean *L. horrida*, perhaps as a growth response to drought conditions.

1912—Lantana subcordata Urb., Symb. Antill. 7:351.
LECTOTYPE (here designated).—Dominican Rep. near Santiago, *Schomburgh 5* (K! [HOLOTYPE: B, destroyed]; ISOLECTOTYPE: P).
Taxonomic disposition.—L. subcordata (Pilose Group)
Discussion.—See Sanders 1989a

1922—Lantana pulchra Larrañaga, Escritos D. A. Larrañaga 1:406. *nom. dub.*
TYPE.—Destroyed.
Taxonomic disposition.—Cannot be determined.
Discussion.—Written in the style of the Linnaeans, the protologue contains only 14 words besides the binominal and provides no features to distinguish it from other published species. As both the specimens and Larrañaga's drawings are destroyed (E. A. Paz, MVFQ, pers. comm.), the name must be treated as a *nomen dubium*.

1934—Lantana tenuifolia Rusby, Phytologia 1:74.
HOLOTYPE.—Bolivia. Bopi River, *Rusby 653* (NY [n.v., dig. photo not available]).
Taxonomic disposition.—L. cujabensis? (see 1847)

1940—Lantana insularis Moldenke, Caribbean Forester 2:16.
HOLOTYPE.—Jamaica. trail from St. Helens Gap to Latimer River, *Maxon & Killip 912* (NY!; ISOTYPE: US!).
Taxonomic disposition.—L. insularis (Setose Group)

1940—Lantana leonardiorum Moldenke, Caribbean Forester 2:17. Published as *L. "leonardorum"*
HOLOTYPE.—Haiti. near Jean Rabel, *Leonard & Leonard 13782* (NY!; ISOTYPES: A!, GH!, US!).
Taxonomic disposition.—L. leonardiorum (Pilose Group)
Discussion.—See Sanders 1989a

1940—Lantana scorta Moldenke, Publ. Carnegie Inst. Washington 522:161.
HOLOTYPE.—Mexico. Queretaro: near San Juan de Río, *Rose et al. 9520* (NY!).
Name misapplied to:
L. horrida (Moldenke *in sched.*)
L. camara × *L. horrida* × *L. hirsuta* (Moldenke 1940)
Taxonomic disposition.—L. hirsuta (see 1844)

1940—Lantana notha Moldenke, Phytologia 1:422.
HOLOTYPE.—Mexico. Sinaloa: Fuerte, *Rose et al. 13573* (NY!).
Taxonomic disposition.—L. notha? (section ?)
Discussion.—Although Moldenke (*in sched.*) applied this name to plants in section *Lantana*, the type appears to be in section *Callioreas*, but the critical character to distinguish sections, mature fruits, is lacking.

1941—Lantana scandens Moldenke, Phytologia 2:18.
HOLOTYPE.—Mexico. Michoacán: Coalcomán: Villa Victoria, Pto. de Aire, *Hinton 12315* (NY!; ISOTYPES: F!, LL!, MO!, NY!, US!).
Taxonomic disposition.—L. scandens or *L. scabrida* (see 1789 Strigose Group)

1941—Lantana brittonii Moldenke, Phytologia 2:52.
HOLOTYPE.—Jamaica. Tweedside, below Moody's Gap, *Harris & Britton 10541* (NY!; SOTYPE: US!).
Taxonomic disposition.—L. scabrida (see 1789)

1946—Lantana minasensis Moldenke, Phytologia 2:138.
HOLOTYPE.—Brazil. Minas Geraes: KM 2 along road from Viçosa to Barroso, *Mexia 4448a* (NY [dig. photo!]; ISOTYPES: MO!, TEX!).
Name misapplied to:
L. nivea (Moldenke 1946)
L. nivea × *L. spp.* Pilose Group (Moldenke 1966, 1972a, 1973a, *in sched.*; Sanders *in sched.*)
Taxonomic disposition.—L. nivea (see 1804)

1962—Lantana kingii Moldenke, Phytologia 8:161.
HOLOTYPE.—Mexico. Oaxaca: 2 km south of Niltepec, *King 1775* (TEX!; ISOTYPE: US!)
Taxonomic disposition.—L. kingii or *L. scabrida* (see 1789, Strigose Group)

1979—Lantana morii Moldenke, Phytologia 41:449.
HOLOTYPE.—Brazil. Bahia: Mun. Camacã: São João do Panelinha, *Santos & Mattos 3304* (LL!; ISOTYPE: NY!).
Taxonomic disposition.—L. nivea (see 1804)

1987—Lantana hodgei R.W. Sanders, J. Arnold Arbor. 68:343.
HOLOTYPE.—Dominica. Fresh Water Lake, elfin forest, *Fosberg 48269* (US!; ISOTYPES: F!, GH!, K, MO!, NY!).
Taxonomic disposition.—L. hodgei (Strigose Group)

2006—Lantana strigocamara R.W. Sanders, in this publication.
HOLOTYPE.—USA. Florida: Dade Co., *Sanders 1450* (FTG!; ISOTYPE: NY!). (Fig. 4)
Taxonomic disposition.—L. strigocamara (*L. spp.* Strigose and Setose Groups × *L. camara* subsp. *aculeata*)

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Book Review

Steven Foster and Rebecca L. Johnson. 2006. **Desk Reference to Nature's Medicine**. (ISBN 0-7922-3666-1, hbk.). National Geographic Books, 1145 17th Street, N.W., Washington, D.C., 20036-4688, U.S.A. (**Orders:** 202-857-7335; http://shop.nationalgeographic.com/). $40.00, 416 pp., 200 color photos, 150 line drawings, 159 maps, 7 5/8" × 9 3/4".

This hefty book is an excellent introduction to medicinal plants for people of all ages. Co-author Steven Foster is a noted medicinal plant expert and photographer. So, it is no wonder that beautiful photographs and clear factual writing grace this collaboration between Foster and *National Geographic* writer and photographer Rebecca L. Johnson. Included are 150 medicinal plants arranged alphabetically by common name. Plants covered include those with common household uses like Aloe (*Aloe* vera), herbal medicines like Saint John's Wort (*Hypericum perforatum*), and plants that are sources of drugs, such as sweet wormwood (*Artemisia annua*), the source of the anti-malarial drug artemisinin. There is even a section devoted to a plant used as a medicine by non-humans. The section on bitterleaf (*Vernonia amygdalina*) describes it use by chimpanzees to rid themselves of parasites. For each plant, the authors include brief botanical descriptions, range maps, Latin names, traditional and current medicinal uses, and information on cultivation and preparation. A sidebar in each section includes interesting tidbits about each plant intended to add to "...a better understanding of human experience with the plant or its relatives." The useful Latin name index includes illustrations of each plant for visual reference. There are also essays that highlight the medicinal plants and ethnobotany of regions from all over the world, including Africa, North America, and the Middle East. Although it is not a comprehensive text book, browsing through this book is an enjoyable way to ground oneself in the basics of phytomedicine and ethnobotany.—*Marissa Oppel, MS, Herbarium Technician, Botanical Research Institute of Texas, Fort Worth, Texas 76102-4060, U.S.A.*

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CRATAEGUS SERIES *PARVIFOLIAE* AND ITS PUTATIVE HYBRIDS IN THE SOUTHEASTERN UNITED STATES

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ABSTRACT

This paper deals with *Crataegus* series *Parvifoliae* (Rosaceae, subfamily Pyroideae) in the main part of its range, the southeastern United States. Two species, *C. uniflora* and *C. brittonii*, are recognized together with one putative interserial hybrid, *C.* ×*vailiae*. A number of other obscure entities are also discussed. The series and constituent species are provided with detailed descriptions, full synonymy, keys to taxa and are typified so far as possible. Line illustrations and county level distribution maps, the latter derived from a database of over 1200 records, are also given for each species treated.

KEYWORDS: *Crataegus*, series *Parvifoliae*, Rosaceae, taxonomic revision, interserial hybrids, southeastern United States

RESUMEN

Este artículo trata de *Crataegus* serie *Parvifoliae* (Rosaceae, subfamilia Pyroideae) en la parte principal de su área, el sureste de los Estados Unidos. Se reconocen dos especies, *C. uniflora* y *C. brittonii*, junto con un híbrido putativo interserial, *C.* _*vailiae*. Se discuten también un número de entidades poco claras. Tanto de la serie como de las especies constituyentes se ofrecen descripciones detalladas, sinonimia completa, claves de los taxa, y se tipifican en lo posible. Para cada especie tratada se dan ilustraciones y mapas de distribución a nivel de condado derivados de una base de datos de más de 1200 registros.

INTRODUCTION

The first author was asked to prepare the *Crataegus* treatment for the *Vascular Flora of the Southeastern United States* only vol. 1 (Cronquist 1980) of which, however, was completed. In spite of the soon defunct status of this flora JBP continued with this *Crataegus* project which is now being issued as a set of accounts usually dealing with individual or a few series, e.g. Phipps (1988, 1998). The third of these is presented here and deals with *Crataegus* series *Parvifoliae*. This series extends well beyond the borders of the flora area, to Texas and Mexico westwards and New York and New Jersey northeastwards; however, it is best represented in the southeastern United States. Here, there is one widespread and abundant species, *C. uniflora*, which is somewhat variable, plus the local *C. brittonii* (perhaps the same as *C. rhodella* of western North Carolina). Several of the names that have been synonymised with *C. uniflora* nevertheless repre-

sent distinct nodes of variation and these will receive explicit comment here. Forms such as *C.* ×*vailiae* and related types, however, appear to represent interserial hybrids with *C. calpodendron* (series *Macracanthae*) but are treated here for convenience.

The primary function of this paper is to provide a taxonomic revision that illustrates the variation within series *Parvifoliae* and its putative interserial hybrids in a synoptic manner. *Crataegus uniflora* has often been illustrated but its more variant forms have not, as with *C. brittonii*, and both are illustrated here as well as the putative interserial hybrid *C.* ×*vailiae*. None of the taxa recognized in this paper, even *C. uniflora*, have ever received detailed range maps so far as can be determined. While the raw information to create dot maps did exist in our database, the scale of work necessary to provide each specimen with its mapping coordinates precluded such an ideal approach and instead, county maps, refined so as to indicate record frequency, were made. An appendix lists one representative specimen per county. A key to all taxa recognized here is also provided. The taxa recognized and their synonyms are typified so far as possible. However, lack of lectotypifiable material for the Ashe names involved has caused familiar difficulties for the typification of his names. In the cases encountered here, resolution through neotypification was not, however, adopted because of the arbitrary aspect of making type choices that would correctly match critically defective protologues. The situation with *C. rhodella* (discussed on p. 433) perfectly exmplifies this. Fortunately, although Ashe names constitute the majority in series *Parvifoliae*, the variation encountered in the exsiccatae and field material seen could all be accommodated within the names of other authors. The synonymy provided is based on names encountered in Palmer (1925). The paper will commence with a description of the series, follow with descriptions of the constituent taxa and close on the putative interserial hybrids.

This work has been made possible by loans of over 1200 specimens from 43 herbaria and the first author has endeavored to see and collect representative exemplars in the field of all the taxa treated in the course of over 20 field trips to the southeastern United States. However, the rarer forms, which apparently have always been rare, were never encountered in fieldwork, and possibly no longer exist. The database of specimens is held at UWO. The taxonomic decisions have been made by the first author (J.B.P.) and the second author (K.D.) has been responsible for creating the distribution maps.

The ultimate resolution of variation in series *Parvifoliae* and its putative interserial hybrids invites a further generation of work in which extensive population studies are supported by chromosome counts, critical morphometric analysis as well as molecular studies. The revisionary treatment presented here thus erects the platform for such work.

TAXONOMIC TREATMENT

series **Parvifoliae** (Loudon) Rehder, Man. Cult. Trees Shrubs, 2nd ed.1940. Sect. *Parvifoliae* Loudon, Arbor. et Frutic. Brit. 2. 1838. Group without rank *Uniflorae* Beadle, *nom. nud.* Biltmore Bot. Stud. 1:117. 1902. TYPE SPECIES: *C. uniflora* Muenchh.

Small, ± xeromorphic shrubs with fine straight thorns. Leaves deciduous; usually nearly epetiolate, petioles glandular or eglandular; blades small, longer than broad, entire, and often with conspicuous black glands on the tips of the teeth; unlobed to shallowly lobed; margins crenate or crenate-serrate; ± pubescent, coriaceous. Inflorescences 1-few flowered, bracteolate, the bracteoles small, caducous, linear, gland-margined, membranous to thinly herbaceous. Flowers 10–18 mm diam.; hypanthium externally dense-tomentose; calyx-lobes foliaceous, us. glandular-serrate, often deeply so, as long as to somewhat longer than the petals; petals ± circular, white; stamens 20, anthers us. ivory to cream; styles us. 5. Fruit up to 12 mm diam., ± orbicular, us. quite hairy, yellowish to ruddy; calyx-lobes conspicuous, patent, glandular-serrate, often deeply so; nutlets 4–5, dorsally grooved, sides plane.

This is a small series confined to North America. It consists mostly of one somewhat variable species, *C. uniflora*, widespread and often common in the coastal plain from Texas to Long Island (N.Y.) with outliers further inland and in Tamaulipas, Mexico. There is also a second, much rarer species, *C. brittonii*, from North Carolina and adjacent states. In addition there are three dubiously placed entities, *C. croomiana*, *C. grossiserrata* and *C. choriophylla* that will receive brief discussion. Of the 15 names assigned by Palmer (1925) to series *Parvifoliae* (as natural group *Uniflorae*), one, *C. choriophylla*, may not belong and is therefore only treated briefly here. This is a very rare and probably extinct Florida endemic tree with distinctly petiolate, thin, strongly toothed, often slightly lobed leaves, 3–5 flowered inflorescences, cream anthers and orange-red fruit. Sargent (1922) doubted that *C. choriophylla* really belongs in series *Parvifoliae*, a doubt which I am endorsing, in which case it is a rare local species or hybrid. *Crataegus ×vailiae*, a putative interserial hybrid with series *Macracanthae*, is treated here for convenience, on account of its foliaceous calyx-lobes.

Small stature, rather glandular plants, small ± unlobed leaves, often uniflorous inflorescences, rather small flowers, ± foliaceous calyx-lobes as long as or longer than the petals and normally non-anthocyanic anthers, are features that characterize this series. Anther color may in practice be described as white, ivory or cream, representing both degree of precision in observation and some natural variation.

Series *Parvifoliae* is perhaps most closely related to series *Triflorae*, and at least in some specimens, shares the characteristic that flowering shoots are leafy shoots of the season and not permanent woody short shoots. However, the plant

parts are so much smaller than those of *C. triflora*, that even casual confusion is not possible. It is actually with smaller members of series *Lacrimatae* that confusion is most frequent. Members of both series are small to medium-sized xeromorphs that are rather glandular, often hairy and often have yellowish fruit. Series *Lacrimatae*, however, may be immediately distinguished by their zigzag twigs, non-foliaceous calyx-lobes much shorter than petals and fewer styles and nutlets.

KEY TO SPECIES

1. Plants often only 1–2 m tall; leaf-blades ± elliptic, 1.6:1 or narrower, unlobed; anthers white to cream _____ 1. **C. uniflora**
1. Plants 3 4 m tall at maturity; leaf-blades broad-ovate or broad-obovate, 1.3:1 or broader, larger leaves usually distinctly, though sometimes only shallowly, lobed; anthers anthocyanic or not.
   2. Lobes of leaves obtuse; margins crenate; sides of nutlets smooth _____ 2. **C. brittonii**
   2. Lobes of leaves sharper; margins with sharp, distinct teeth; sides of nutlets ± eroded _____ 3. **C. ×vailiae**

1. Crataegus uniflora Muenchh., Der Hausvater 5:147. 1770; non *C. uniflora* Du Roi, Der Harbkesche Baumzucht, ed. 1:184. 1771. (**Figs. 1, 2, 3, 4, 7**). TYPE: U.S.A. GEORGIA. Crawford Co.: ca. 2 mi SW of Roberta, 13 Apr 2006, *J.B. Phipps 9060* (NEOTYPE designated here: UWO; ISONEOTYPES: A, BRIT, GA, MO, NCU, US). Muenchhausen's original material would be at LINN according to TL-2 but none could be located of this species.

Crataegus parvifolia Aiton, Hort. Kew. 2:169. 1789. TYPE: Specimen labeled '*C. tomentosa* Linn.' with '*tomentosa*' crossed out; no further information except a 'type' label (LECTOTYPE designated here: Banksian Herb., BM).

Crataegus parvifolia var. *florida* Loudon, Arbor. Frut. Brit. 2:842 (no Loudon herbarium exists and this variety has not been neotypified; see discussion).

Crataegus parvifolia var. *grossulariaefolia* Loudon, Arbor. Frut. Brit. 2:842 (this Loudon variety has also not been neotypified; see discussion).

? *Crataegus bisulcata* Ashe, Bull. North Carolina Exp. Stn. 175:112. 1900.

Crataegus earlei Ashe, Bull. North Carolina Exp. Stn. 175:112. 1900.

Crataegus grossiserrata Ashe, Bull. North Carolina Exp. Stn. 175:112. 1900.

Crataegus raleighensis Ashe, Bull. North Carolina Exp. Stn. 175:112. 1900.

Crataegus armentalis Beadle, Biltmore Bot. Stud. 1:117. 1902. TYPE: U.S.A. ALABAMA. Marshall Co.: near Albertville, no date, *T.G. Harbison 3281*, fruiting specimen (LECTOTYPE designated here: US).

Crataegus gregalis Beadle, Biltmore Bot. Stud. 1:118. 1902. TYPE: U.S.A. NORTH CAROLINA. Buncombe Co.: flats of French Broad River, 18 Sep 1900, *Biltmore Herb. 1270b*, in part (LECTOTYPE designated here: US 969361).

Crataegus pentaneura Ashe, J. Elisha Mitchell Sci. Soc. 19:12. 1903.

Crataegus smithii Sarg., Trees & Shrubs 2:67. 1903. TYPE: U.S.A. PENNSYLVANIA. Delaware Co.: Lownes Run, Springfield, 21 May 1902, *B.H. Smith 201* (LECTOTYPE designated here: A).

Crataegus trianthophora Sarg., Trees & Shrubs 2:11. 1907. TYPE: U.S.A. MISSOURI. Shannon Co.: near Grandin, (lectotype to be designated by Phipps et al., in press).

? *Crataegus croomiana* Sarg., J. Arnold Arbor. 3:202. 1922. TYPE: U.S.A. FLORIDA. Leon Co.: near Tallahassee, 15 Apr 1920, *T.G. Harbison 5710* (HOLOTYPE: A).

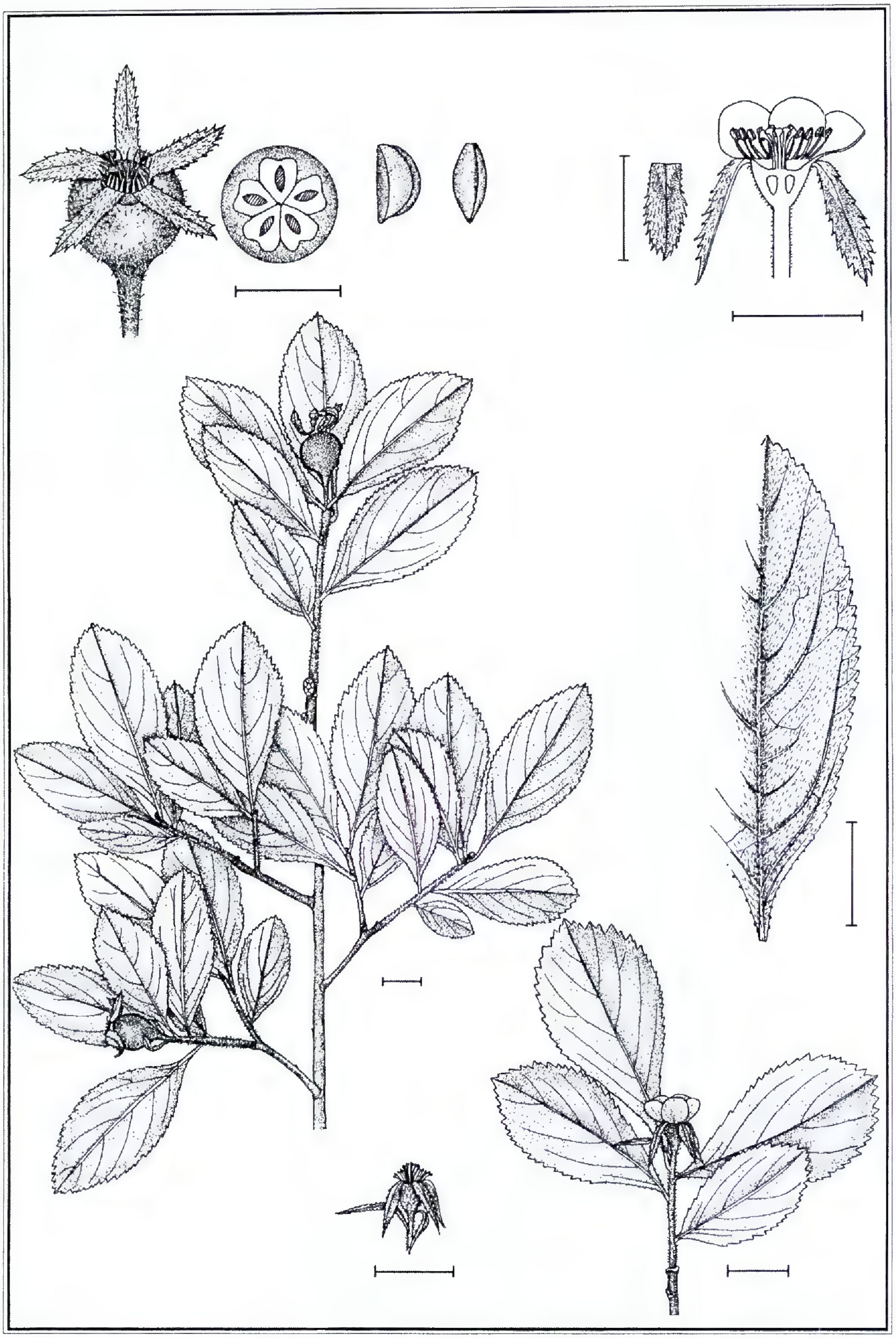


FIG. 1. Typical leaf form in *Crataegus uniflora*. Fruiting specimen, fruit details and leaf magnifications from *Smith 1350* (MO, UWO); flowering shoot and flower details from *Sherman 214* (TENN). S. Laurie-Bourque del.; scale bars = 1 cm.

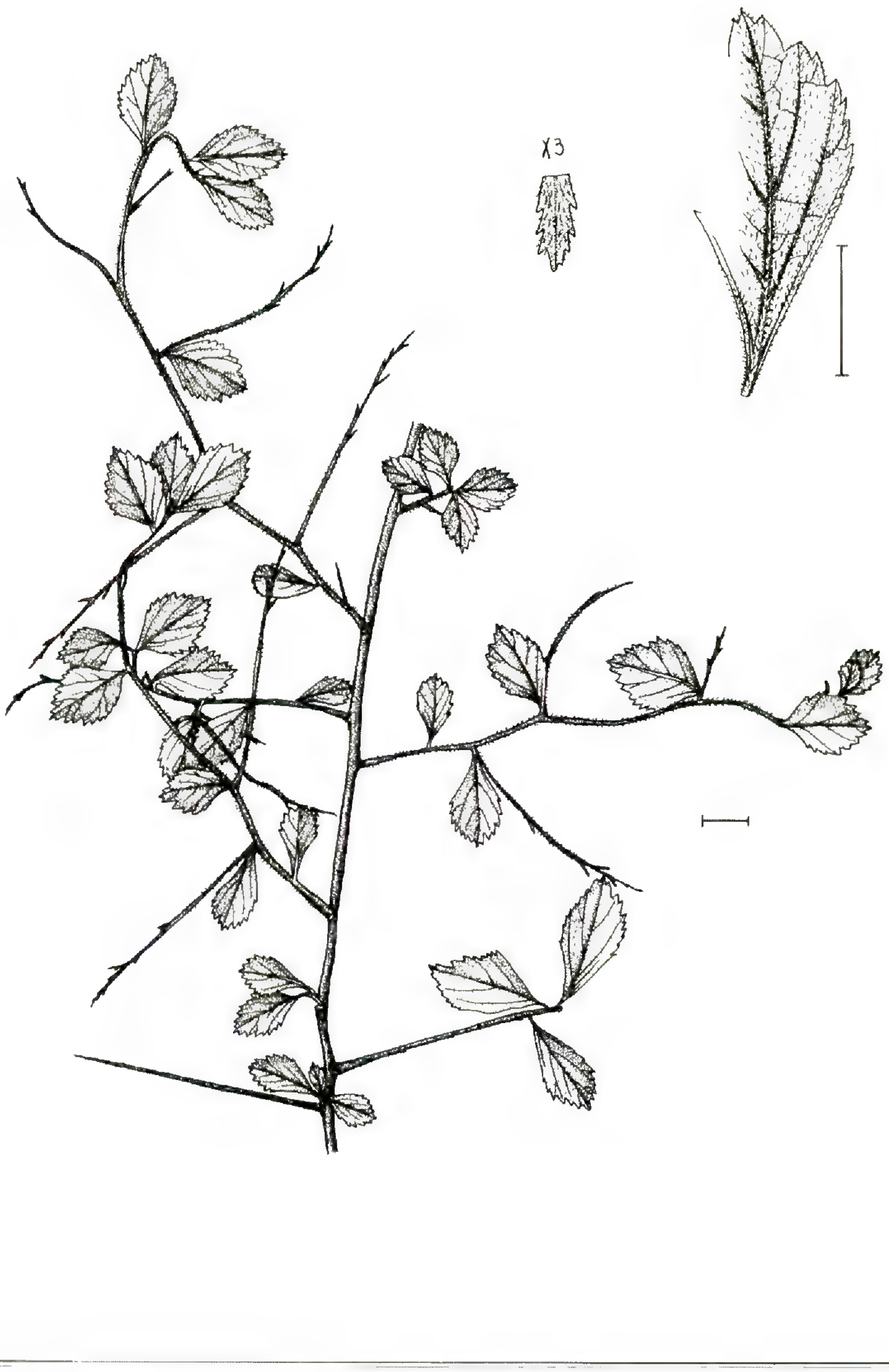


FIG. 2. Young shoots of *Crataegus uniflora* clearly illustrating developing thorns, which possess bract-like appendages; from *Chapman s.n.* (US). S. Laurie-Bourque del.; scale bars = 1 cm.

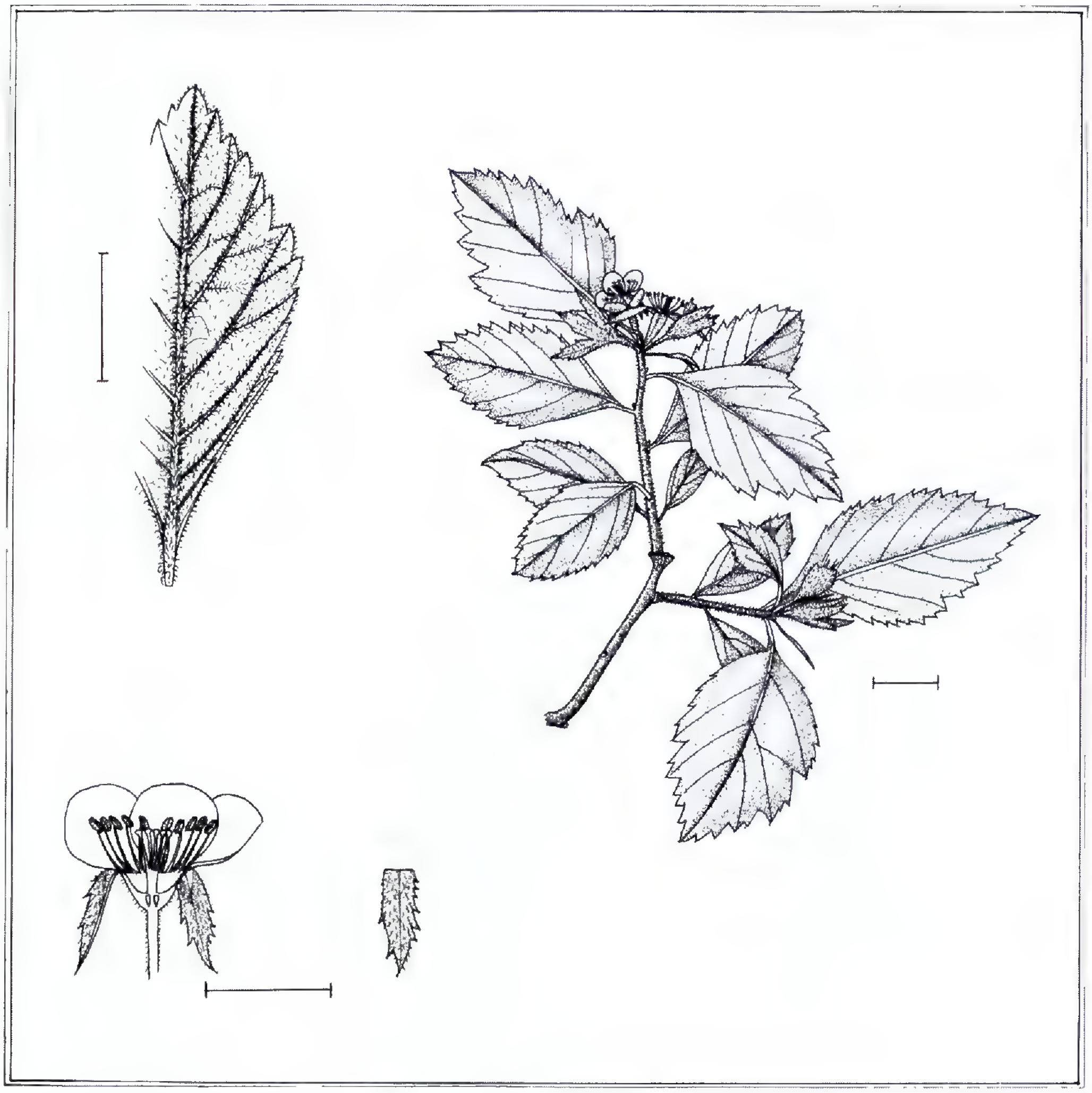


FIG. 3. *Parvifolia*- or *trianthophora*-like form of *C. uniflora* showing several-flowered inflorescence form with pointed leaves; from *Murrill 7* (MO). S. Laurie-Bourque del.; scale bars = 1 cm.

Shrubs, us. under 2 m tall at maturity, less commonly to 3 m and occasionally reaching 5 m; extending shoots densely appressed-pubescent; one-year old twigs brown, older grayish; thorns 3–5(–8) cm long, usually plentiful, ± straight, needle-like, occasionally absent, black at 1 yr old; young thorns commencing as soft, rapidly growing, needle-pointed-shoots with small linear bracts, often curved at first and then straightening out (Fig. 2). Leaves deciduous; petioles very short to lacking, glandular or not; blades (1–)1.5–3(–6) cm long, narrow-elliptic, elliptic, obtrullate, spatulate, oblanceolate or narrowly rhomb-elliptic, occasionally suborbiculate; cuneate at the base, obtuse to broadly acute at the tip; entire; margins crenate to dentate, with variably caducous black gland-tipped teeth though sometimes eglandular even young; venation semi-

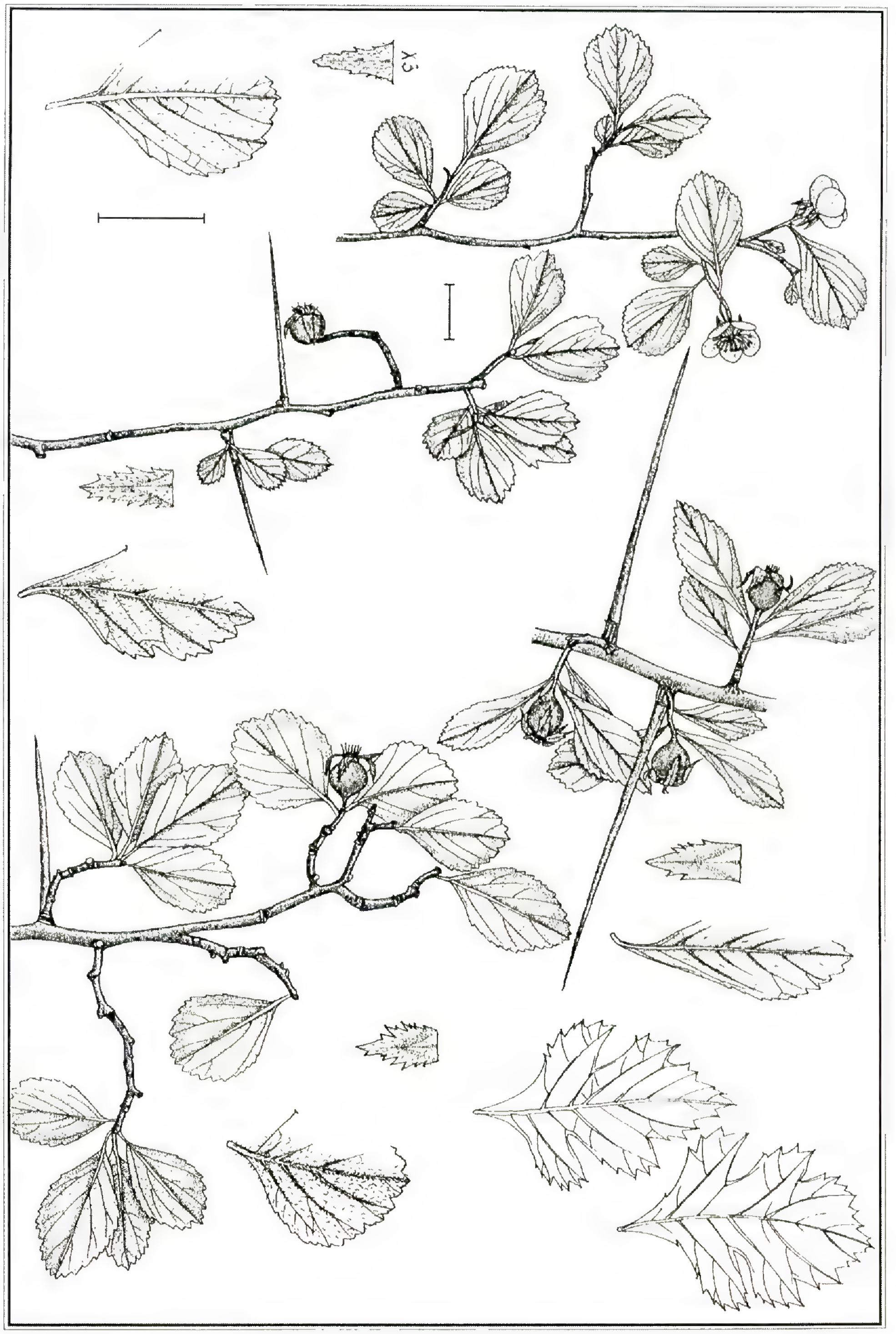


Fig. 4. Various morphotypes of *Crataegus uniflora sens. lat.*, showing variation in thorns and leaf-shape as well as lobed leaves with veins to sinuses on extension shoots. From left: somewhat broad-leaved form—*Phipps 7677* (UWO); possible *arenicola* form—*Shinners 12651* (GA); *C. croomiana* form—*Murrill in FLAS 34624*; *C. grossiserrata* form with two extension shoot leaves top right—*Bozeman 7188* (NCU). S. Laurie-Bourque del.; scale bars = 1 cm.

camptodromous, lateral veins 3–4(–5) per side, ± impressed; densely scabrous-pubescent above especially when young, below ± densely pubescent on the veins, thinly to moderately pubescent on the surface; often somewhat glossy above at maturity, ± coriaceous. Inflorescences 1–3(–5) flowered; pedicels pubescent, bearing us. one or two small, caducous, linear, membranous to herbaceous, gland-margined bracteoles. Flowers 10–15 mm diam.; hypanthium strongly tomentose externally, sometimes bearing a membranous to herbaceous, linear, caducous, gland-margined bracteole; calyx-lobes us. longer than the petals, 2–4 mm wide, ± foliaceous, narrowly triangular, ± deeply glandular-serrate except in rare aberrant forms, thinly pubescent on both sides; petals ± circular, white; stamens 20, anthers white to cream, except in rare, possible interserial hybids; styles 5. Fruit 8–10(–12) mm tall, ± orbicular, tomentose, yellow-green, yellow, or yellow orange to ruddy; flesh firm, dry or mealy; calyx-lobes to ca. 7 mm long, persistent, conspicuous, patent; nutlets 4–5, dorsally furrowed, laterally smooth.

Common name.—One-flowered hawthorn.

Distribution.—This species is widespread in the southeastern part of the United States (Fig. 7) from Long Island (New York) to eastern Texas with an outlier in Tamaulipas (Mexico). Inland it reaches the line Oklahoma, Missouri, southern Ohio, West Virginia. There is a remarkable disjunction in the Mississippi embayment between trans-Mississippian and cis-Mississipian populations that mirrors a similar pattern in *C. spathulata* (Phipps 1998). *Crataegus uniflora* is usually found in sand barrens and open scrubby woodland.

Crataegus uniflora should be easy to identify on account of its small size, unusually large sepals (relative to the petals), uniflorous or few-flowered inflorescences and yellowish to ruddy fruit. However, it has sometimes been confused with some members of series *Lacrimatae* which include similar sized xeromorphs, also of sand-plains of the southeastern United States as is amplified under the series discussion. Sterile plants can most easily be distinguished from small, sterile plants of *C. berberifolia* Torrey & A. Gray, a superficially similar member of series *Crus-galli*, by the smaller number of lateral veins on the leaves. An interesting feature of this species is the occasional deep lobing of extension-shoot leaves, even narrow ones, with veins to sinuses. The United States National Champion of *C. uniflora* in 1998, from Gainesville, Florida, measured 18 ft tall in 1992, an unusually great stature for this species.

Crataegus uniflora is somewhat variable as befits a common species, in plant size, precise leaf shape (when strikingly obtrullate with acute tip or when suborbiculate presenting a quite different facies), number of flowers to an inflorescence (usually one), and anther color (usually ivory to cream). However, 15 specific names listed under series *Parvifoliae* (Palmer 1925), 11 of which are accounted for in this paper, attest to this variation and in some cases may represent valid, perhaps apomictic, microspecies or, as we shall see, perhaps interserial

hybrids. *Crataegus uniflora* had never hitherto been typified perhaps partly because the protologue is unusually diagnostic for one of the period on *Crataegus*. The protologue clearly represents *C. uniflora* as construed here. I have thus neotypified on what I regard as the widespread and common form: a small shrub, with coriaceous, ± spatulate to narrow obovate leaves, usually numerous fine straight thorns, 1–2 flowered inflorescences, glandular-pectinate sepals, anthers white to cream and yellow-green to yellow-orange fruit. Among this group are some particularly dwarf forms of *C. uniflora* from laterites in Georgia that have been observed with over one hundred flowers when less than 0.3 m tall.

There are two main kinds of deviation from the above norm, firstly, a group where multi (3–6)-flowered inflorescences occur and second, odd forms very like the putatively typical group but with often small and unlobed sepals. We will deal with the multiflowered types first. The most striking of those that can confidently be included in *C. uniflora* is *C. parvifolia* Aiton, lectotypified above, its type with 2–6 flowered inflorescences. A similar form is *C. trianthophora*, nicely illustrated by Faxon in Sargent's protologue, scattered through the range of the species and being the main form of *C. uniflora* in Missouri. Multiflowered forms such as *parvifolia* and *trianthophora* represent one extreme of variation in the *uniflora* complex but the existence of two- and three-flowered inflorescences on some plants makes any varietal recogntion dubious at this point. Generally, forms with multiflowered inflorescences have larger and relatively broader leaves than *C. uniflora* but this is not the case with the *parvifolia* complex. Multiflowered specimens with broad and slightly lobed leaves and unpitted nutlets are however, assigned to *C. brittonii*.

The other main kind of variation is exemplified by *C. croomiana* (Figs. 4, 9), whose type comes from Tallahassee, Florida, and which has the distinction of pink anthers and entire to merely glandular-serrate calyx-lobes. Out of the approximately 1200 specimens of the *uniflora* complex that in the UWO database, ten have ± entire calyx-lobes and come from the northern Florida counties of Alachua, Gadsden, Leon and Liberty. The foliage and non-geniculate twigs are, nevertheless, quite typical for *C. uniflora*. These specimens may be part of the variation that Murrill (1942) noticed. Further investigation is required to see whether *C. croomiana*, plus perhaps some other names, should be upheld, possibly as sporadic interserial hybrids with members of series *Lacrimatae*. *Crataegus bisulcata* from North Carolina has similar calices though 'rounder' leaves while the striking *C. grossiserrata* (Fig. 4) with a type from 'Florida' (no location) also has similar calyx-lobes, though often orbicular (unusual in this series) extension shoot leaves and particularly strong and sharp leaf-teeth. A feature of these broad, extension-shoot leaves is a tendency to deep lobing, sometimes with veins to sinuses. If populations of such forms could be

located today, studied and shown to be worthy of name recognition, they might prove to be the same as the untypified var. *grossulariifolia* of Loudon.

Names listed in the synonymy but so far undiscussed all belong to entities more like typical *C. uniflora* as defined earlier and we present below a table illustrating some of the differences among these and other forms (Table 1). Such is the homonymous *C. uniflora* Du Roi, judging by the protologue obviously the same species as the Muenchhausen one, and is not worth neotypifying. The differences among the remainder are small and apparently not sharp, but it is possible that they represent local, perhaps apomictic, races. The information in this table is taken from protologues, amended by personal observation. Uncommon forms with suborbiculate leaves may be the same as the untypified var. *florida* of Loudon but, as these grade into typical forms, are not considered worthy of recognition.

2. Crataegus brittonii Eggl., Bull. Torrey Bot. Club 36:640. 1909. (**Figs. 5, 8**). TYPE: U.S.A. NORTH CAROLINA. Buncombe Co.: Biltmore, 15–18 Sep 1908, *W.W. Eggleston 4134* (HOLOTYPE: NY; ISOTYPE: NY).

? *Crataegus arenicola* Ashe, J. Elisha Mitchell Sci. Soc. 17:5. 1900.
? *Crataegus rhodella* Ashe, J. Elisha Mitchell Sci. Soc. 18:19. 1902.

Shrub, slender, to 3 or 4 m tall; thorns 3–5 cm long, often numerous, ± slender, ± straight to slightly recurved, blackish; extending shoots pubescent, at one year glabrous, somewhat shiny gray-brown, older becoming gray. Leaves deciduous; petioles 3–6 mm long, flared into the blade, pubescent; blades 2.0–3.5 cm long, elliptic-rhombic to broad elliptic-rhombic in general shape, generally widest near the middle, apex rounded to subacute, bases broad-cuneate; lobes 0–1(–2) per side, if present, shallow, rounded; margins crenate-serrate, the teeth with caducous gland-tips; venation ± craspedodromous, 3–4 main lateral veins per side; somewhat coriaceous, appressed-pubescent and dark green adaxially, soft pubescent and paler green abaxially; indumentum variably persistent with age. Inflorescences 2–6 flowered; branches dense-pubescent, bearing narrow, gland-bordered bracteoles. Flowers 14–18 mm diam.; hypanthium dense-pubescent; calyx lobes adaxially pubescent, narrow-triangular, margins ± deeply glandular-serrate; stamens 20, anthers ivory; styles 3–5. Fruit subglobose, ca. 14 mm high, red or ruddy, sometimes ripening to dull brown, pubescent; calyx-lobes reflexed; nutlets 3–5, lateral faces plane, dorsally ridged.

Common name.—Britton hawthorn.

Distribution.—*Crataegus brittonii* is known from North Carolina, Georgia, Tennessee and Alabama. It is found in brushy places.

Ashe's protologue of *C. rhodella*, for which no specimens were actually cited, states that this species comes from western North Carolina, along the Cullasagee River, near Franklin, Macon Co. and the Little Tennessee River, where, although said to be common, it has not been found since that time. Although we have

TABLE 1. Diagnostic features of named forms in *Crataegus* series *Parvifoliae*, from protologues.

	Stature	leaf shape	infl., fl. no.	calyx margins	anther colour	style no.	fruit colour	other
C. arenicola	shrub	ovate-rhomb.	1–5	lacin.	?	?	ruddy	
C. armentalis	0.3–1m	cuneate-spatul.	1–2(–3)	gl.	pale y.	3–5	red	
C. bisulcata	?	rounded	?	nearly entire	?	?	gr.-y.	
C. brittonii	3–4m	ovate to br. ovate	1–6	lacin.	wh.	5	brown	
C. choriophylla	arborescent	obov.-elliptic	3–5	gl.-serrate to .lacin	wh.	4–5	or.-red	thornless
C. croomiana	1.5–2m	obov.-rhomb.	1	nearly ent. to lacerate	pk.	5	?	
C. earlei	shrub	oblanc., obl.-cun.	1	serr.	wh.-cr.	?	?	?
C. gregalis	1–3m	cun., obov.-obl.	1–2(–3)	incised	?	3–5	ruddy	pyriform fruit
C. grossiserrata	small	obov. spatul.	1	±entire	?	-	?	coarse leaf teeth
C. raleighensis	shrub	obov.-orbic.	1–(2–3)	serr. to lacerate	?	?	yell-gr.	
C. rhodella	to 3m	rhomb., ovate	3–6	gl.-serr	rose-pur.	3–5	ruddy	diam. fls. 18mm
C. smithii	1–2m	obov.	1	gl.serr.	pale y.	5–6	or. to or-gr.	flowers 7–10 days before *uniflora*
C. trianthophora	0.6–1.2m	obl.-obov.	3	gl.-serr.to -lacin.-	pale y.	3–4	ruddy	

abbreviations used

br. = broad
cr. = cream
cun. = cuneate
ent. = entire
fls. = flowers
gl. = glandular
gr. = green
lacin. = laciniate
obl. = oblong
oblanc. = oblanceolate
obov. = obovate
or. = orange
pk. = pink
pur. = purple
serr. = serrate
spat. – spatulate
wh. = white
y. = yellow

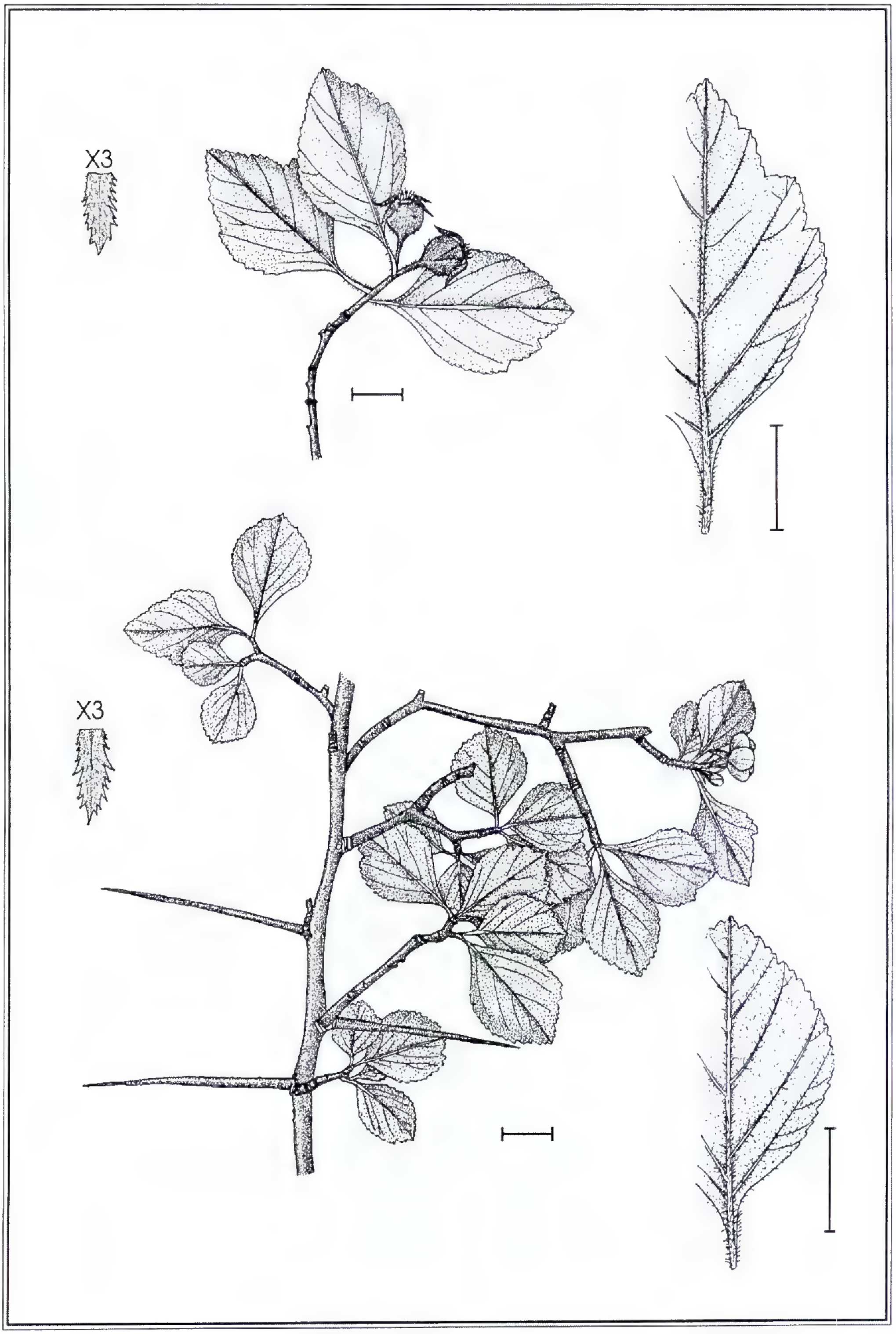


FIG. 5. *Crataegus brittonii* with magnification of calyx-lobes and leaves; fruiting from *Small s.n.* (NY); flowering from *Biltmore Herb. s.n.* (DOV). S. Laurie-Bourque del.; scale bars = 1 cm.

located none of this material, the protologue is sufficiently detailed that *C. rhodella* is likely conspecific with *C. brittonii*, the only significant difference appearing to be anther color (rose in *C. rhodella*) and, if conspecific, *C. rhodella* would become the correct name for the species. Because neither the type of *C. rhodella*, nor any authentic material annotated by Ashe, can be located, however, neotypifying this species is problematical. Two flowering specimens collected by Harbison (*Harbison 11589* and *14999*) from Dillsboro, Jackson Co., North Carolina are labelled *Crataegus rhodella* and with such a prominent collector there is necessarily some presumption that he was correct and that their anthers were pink. However, the label data is silent on anther color and the leaf form resembles *C.* ×*vailiae*. Pink-anthered *brittonii*-like forms should nevertheless be carefully sought out by those that have the resources to do so. *Crategus arenicola* appears to be a smaller form of *C. rhodella* but in the absence of authentic material and similar difficulties surrounding neotypification one cannot be sure. A final group of larger plants (also 3–4 m tall) with longer petioles, ovate to broad-ovate leaves with usually sharply toothed margins, also deeply glandular-serrate sepals and somewhat eroded nutlets is sufficiently different that they are referred to the putative interserial hybrid, *C.* ×*vailiae* Britton, below.

3. Crataegus ×vailiae Britton, Bull. Torrey Bot. Club 24:53. 1897. (**Figs. 6, 10**).

TYPE: U.S.A. VIRGINIA: banks of Roanoke River, 29 May 1890, *A. Brown, s.n., T. Hogg, A.M. Vail, M. Timmerman, N.L. Britton and E.G. Britton* (LECTOTYPE designated here: NY).

Crataegus missouriensis Ashe, Bull. North Carolina Exp. Stn. 175:100. 1900. TYPE: U.S.A. MISSOURI. Shanon Co.: Montier (NEOTYPE to be designated by Phipps et al. in press).

Crataegus conjungens Sarg., J. Arnold Arbor. 3:200. 1922. TYPE: U.S.A. VIRGINIA. Alleghany Co.: Clifton Forge, 23 May 1919, *T.G. Harbison15078 (-9)* (HOLOTYPE: A; ISOTYPE: NCU).

Bushes to 2–4(–5) m tall; thorns to 2.5 cm long; extending twigs densely pubescent, at 1 yr thinly pubescent; at 2 yrs glabrous, dark, shiny blackish-brown to dark gray; older dark gray; mature bark not recorded; thorns absent or 4–6 cm long, few, straight to slightly recurved, somewhat narrow, black at two years. Leaves deciduous; petioles 3–6 mm long, pubescent, occasionally glandular; blades 4–5(–6) cm long, elliptic to rhomb-elliptic in general shape, symmetrical about the middle but sometimes either end widest; subacute at the tip, tapered to a cuneate base; with up to 3 extremely shallow lobes per side; margins with large acute or subacute teeth except near the cuneate base; margins eglandular (on material seen by me), teeth normally sharp; venation craspedodromous with 4–6 veins per side; appressed pubescent above, more obscurely so at maturity, very thin pubescent (glabrescent) on the surface below but veins below persistently dense pubescent; somewhat coriaceous at maturity. Inflorescences 2–8(–12) flowered; branches very dense appressed-pubescent, bearing a few caducous, linear, membranous, gland-margined bracteoles or larger (to 15 × 3 mm) more herbaceous bracteoles in the lower parts; late-flowering.

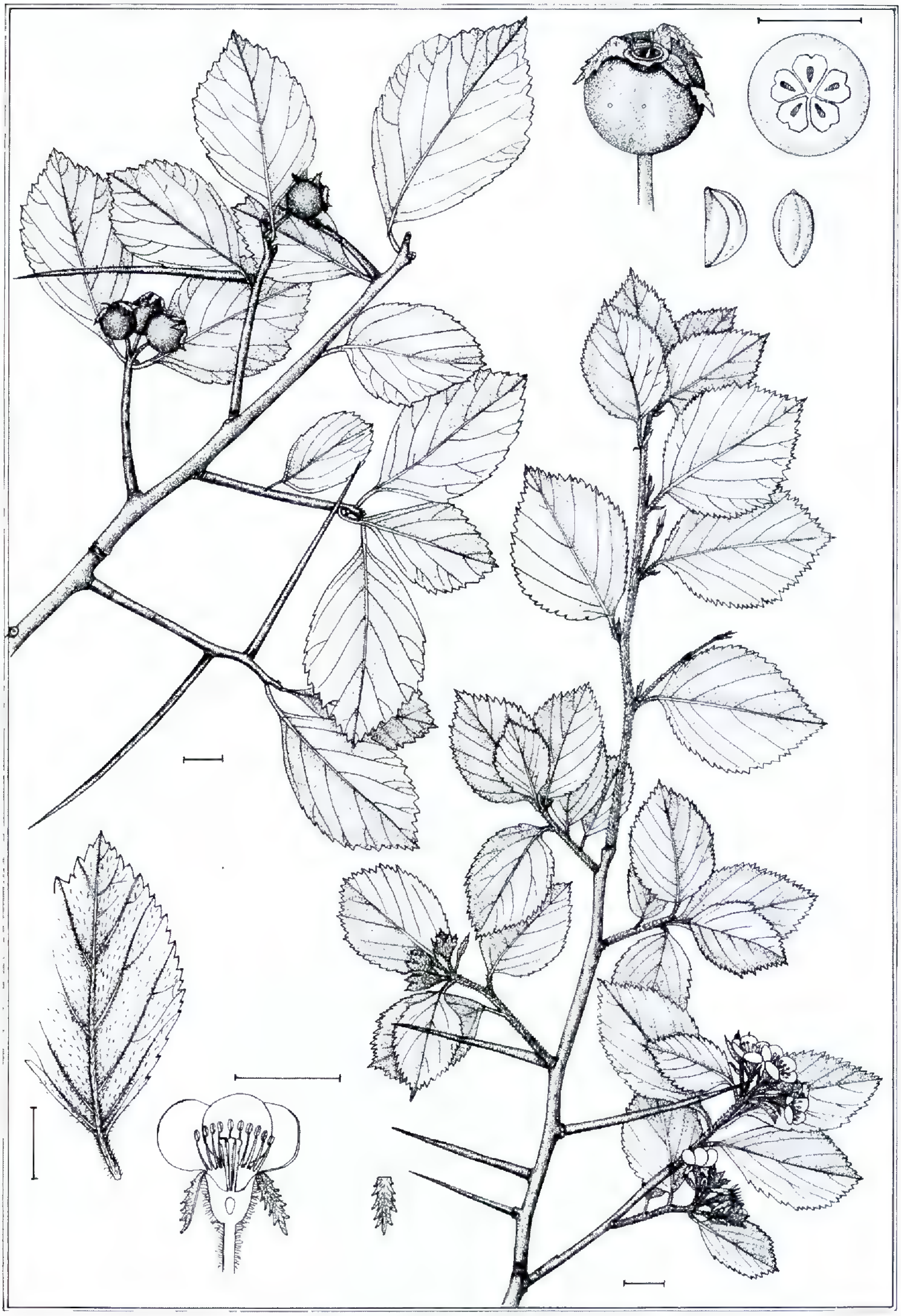


FIG. 6. *Crataegus* × *vailiae* specimens indicating somewhat larger, more acute and more sharply toothed leaves than *C. brittonii*; fruiting from *Sargent s.n.*, 1885 (A); flowering from *Harbison 15071* (NCU). S. Laurie-Bourque del.; scale bars= 1 cm.

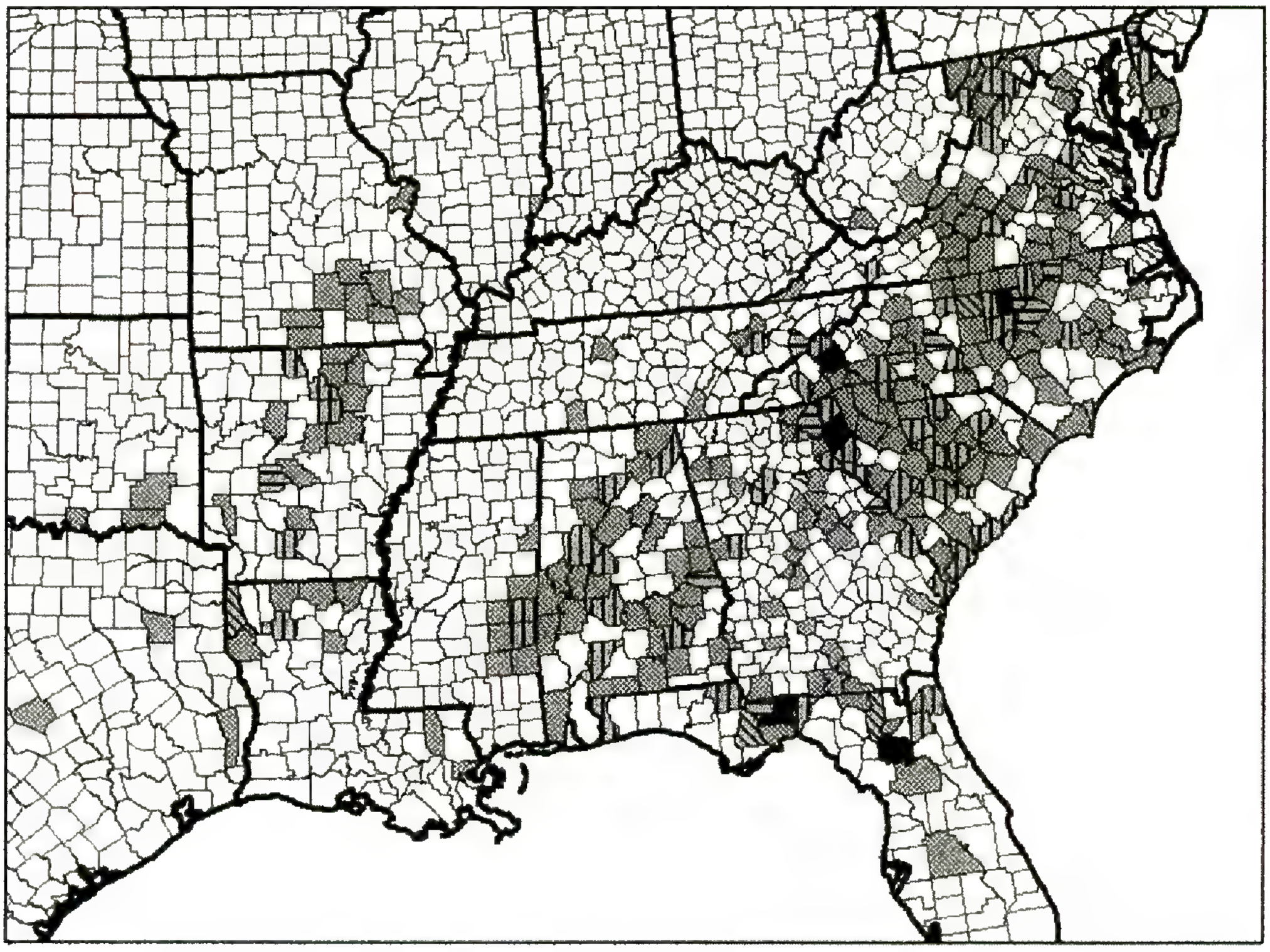


FIG. 7. County level distribution map of *C. uniflora* in the southeastern United States based on 1160 records. Not mapped north of Ohio River or Maryland and Delaware.

Flowers 15–20 mm diam.; hypanthium densely spreading pubescent; calyx-lobes 6–8 mm long, narrowly triangular, somewhat foliaceous, abaxially slightly pubescent, margins deeply glandular-serrate; petals ± circular, white; stamens 20, anthers cream, pink or red; styles 3–5. Fruit 7–9 mm thick, subglobose, hairy, straw yellow to ruddy at maturity in cultivation at Kew, recorded as deep red and succulent in Missouri (Bush); calyx-lobes long, margins ± pectinate, reflexed in fruit; nutlets 3–5, dorsally grooved, laterally usually shallowly pitted.

Common name.—Vail's hawthorn.

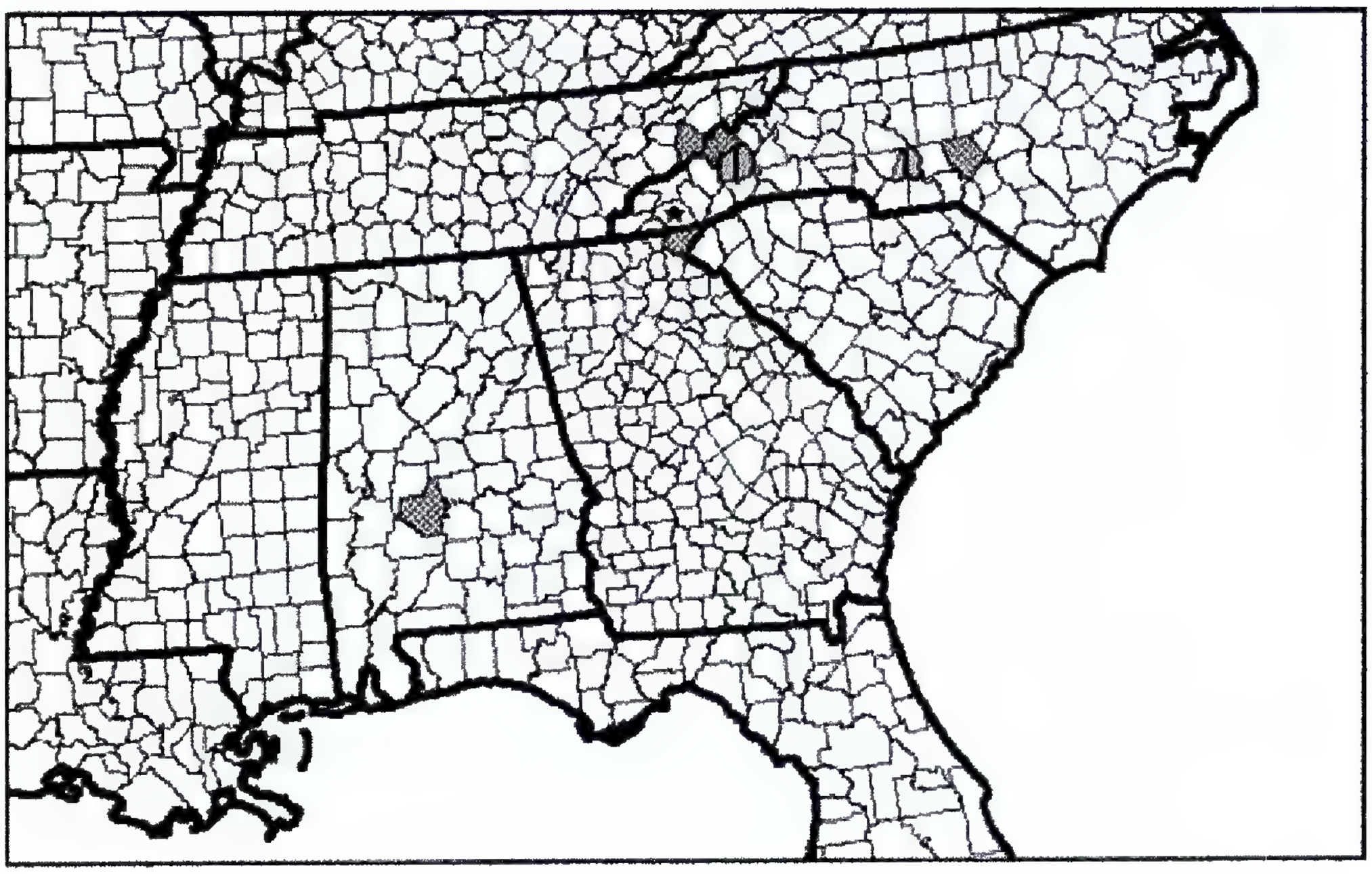


FIG. 8. County level distribution map of *C. brittonii* based on 17 records seen and including literature references for *C. rhodella* from Macon Co., NC.

Distribution.—Vail's hawthorn has a sparse distribution in the United States and is primarily a species of southern Appalachia in Virginia, Tennessee, North Carolina and Georgia. It is also known from Missouri and Arkansas. It occurs in brushy places or on riverbanks.

With its similarities to *C. uniflora*, *C. ×vailiae* may be a hybrid between that species and an entity in series *Macracanthae*, most likely *C. calpodendron*, on account of its laterally eroded nutlets and late anthesis. *Crataegus conjungens* appears to be a smaller form of *C. ×vailiae*.

Vail's hawthorn is an attractive plant in flower and fruit when well grown, especially in forms with reddish fruit, the color nicely set off by the glossy foliage. It is named for Anna Murray Vail, librarian at the New York Botanic Garden, who was one of the collectors of the type material.

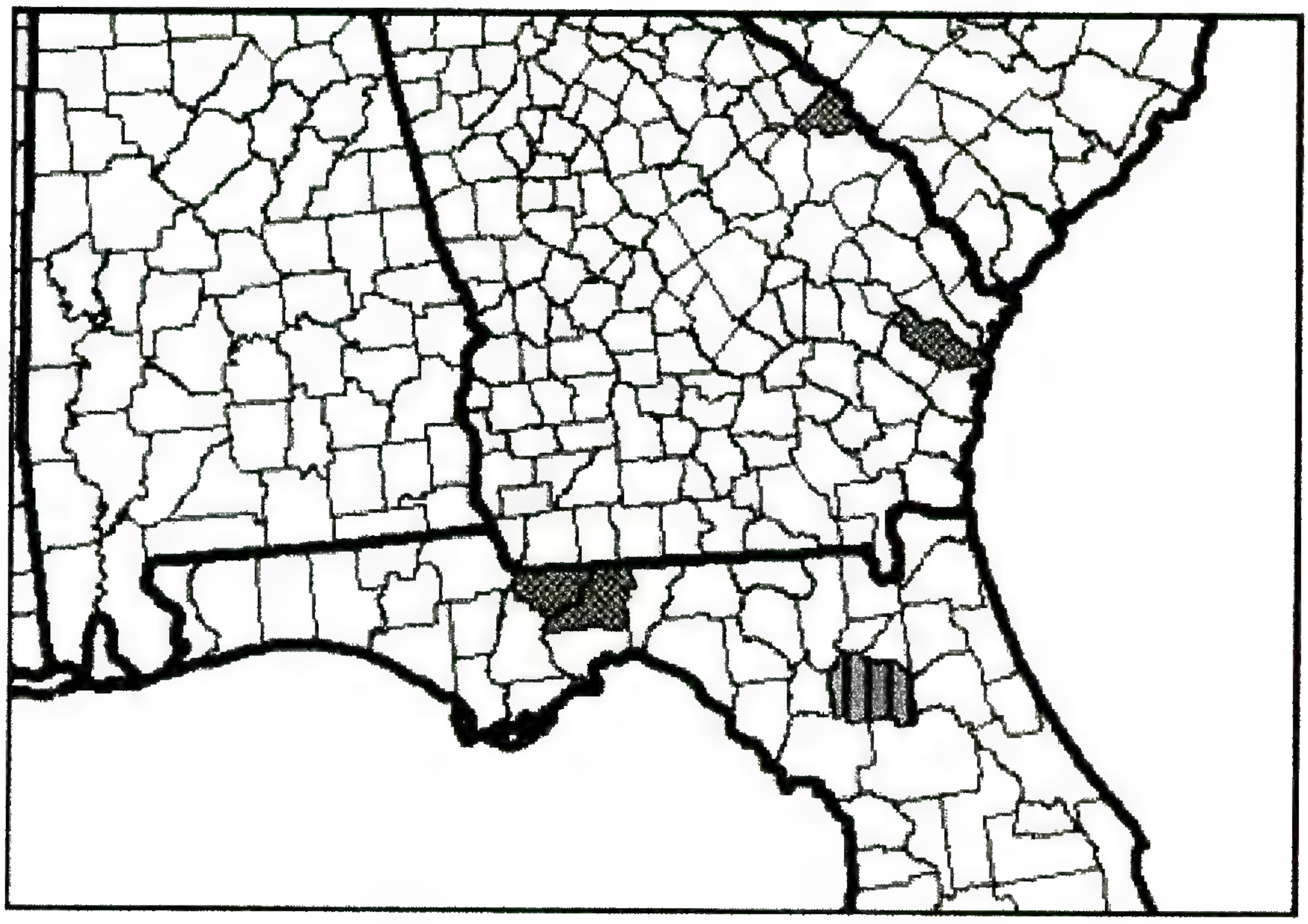


FIG. 9. County level distribution map of *C. croomiana* based on 16 records.

APPENDIX: FURTHER CITED SPECIMENS

Crataegus ×vailiae *Britton*

ARKANSAS. Hempstead Co.: 1905/04/21, *Bush, B.F. 14* (HUH). **GEORGIA. Baldwin Co.:** 1914/05/06. *Harbison, T.G. 1544* (HUH). **Morgan Co.:** 1978/05/06, *Hill, J.W. 406* (FLAS). **MISSOURI. Ripley Co.:** 1892/07/23, *MacKenzie, K.K. 400* (NYBG). **Shannon Co.:** 1905/05/17, *Bush, B.F. 3F* (CM). **NORTH CAROLINA. Burke Co.:** 1957/06/11, *Bell, C.R. 8759* (NC). **Guilford Co.:** 1927/06/29, *Manning, W.E. and Wiegand, K.E. 1383* (HUH). **Jackson Co.:** 1901/05/23, *Ashe, W.W. 32* (HUH). **Lincoln Co.:** 1957/06/11, *Bell, C.R. 8891* (GA). **Macon Co.:** 1919/05/10, *Harbison, T.G.* (A). **Richmond Co.:** 1954/05/12, *Melvin, L.* (NCU). **Rowan Co.:** 1904/05/17, *Beadle, C.D. 10103* (NYBG). **Swain Co.:** 1914/05/18, *Harbison, T.G. 1591* (A). **Vance Co.:** 1874/04, *Faxon, C.E.* (MO). **Wake Co.:** 1938/04/25, *Godfrey, R.K. 3758* (MO). **VIRGINIA. Alleghany Co.:** 1909/05/19, *Eggleston, W.W. 4378* (NYBG). **Amelia Co.:** 1969/07/24, *Johnson, M.F. 3929* (VCU). **Buchanan Co.:** 1909/10/21, *Eggleston, W.W. 5594* (NYBG). **Franklin Co.:** 1890/05/29, *Brown, H.A. et al* (NYBG). **WEST VIRGINIA. Summers Co.:** 1933/05/13, *Boone, W. 564* (WVU).

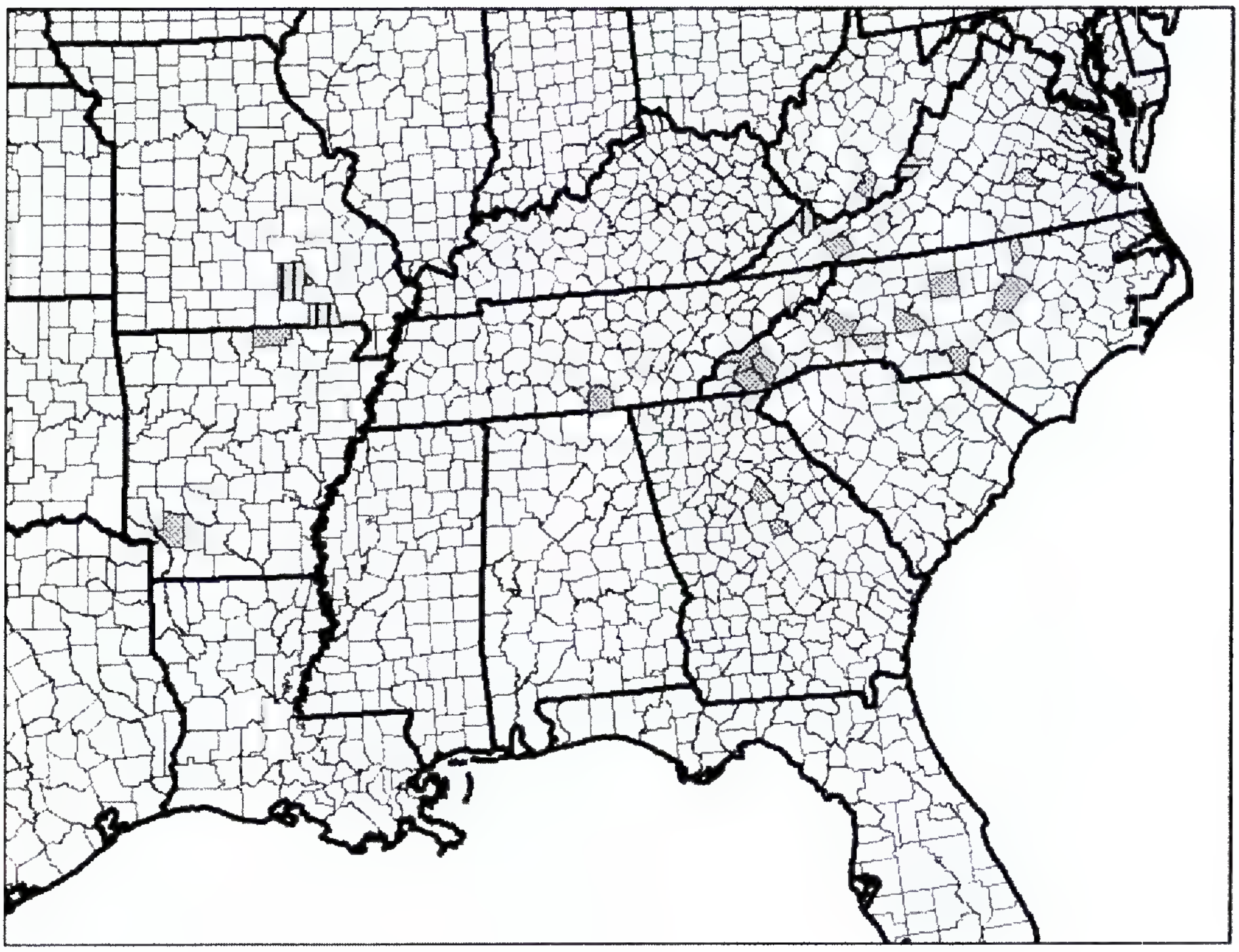


FIG. 10. County level distribution map of *C.* × *vailiae* based on 39 records.

Crataegus brittonii Eggl.
GEORGIA. Rabun Co.: 1893/08/04, *Small, J.K.* (NY). **NORTH CAROLINA. Buncombe Co.:** 1934/05/26, *Palmer, E.J. 42550* (NY). **Madison Co.:** 1908/09/21-22, *Eggleston, W.W. 4162* (NY). **Stanley Co.:** 1909/10/24, *Eggleston, W.W. 5615* (NY). **TENNESSEE. Cocke Co.:** 1897/08/24, *Kearney, T.H., Jr. 596* (NY).

Crataegus uniflora Muenchh.
ALABAMA. Bibb Co.: 1977/04/14, *Sessler, A.H. 1004* (ALU). **Blount Co.:** 1966/06/28, *Clark, R.C. and Hare, T.B. 4077* (NCU). **Bullock Co.:** 1967/07/19, *Clark, R.C. 16433* (NCU). **Chambers Co.:** 1967/06/02, *Clark, R.C. 13470* (NCU). **Choctaw Co.:** 1964/04/20, *McDaniel, S. 4222* (IBE). **Coffee Co.:** 1967/07/04, *Clark, R.C. 15618* (NCU). **Covington Co.:** 1967/06/20, *Clark, R.C. 14402* (NCU). **Crenshaw Co.:** 1931/04/16, *Palmer, J.P. 38686* (MO). **Cullman Co.:** 1891/06/13, *Sudworth, G.B.* (US). **Dallas Co.:** 1920/04/19, *Harbison, T.G. 15275* (NCU). **DeKalb Co.:** 1955/05/06, *Churchill, J.A.* (MSC). **Escambia Co.:** 1969/04/18, *Harmon, C. 046* (NCU). **Greene Co.:** 1966/08/06, *Clark, R.C. 6954* (NCU). **Hale Co.:** 1966/06/07, *Will-*

iams, N. 337 (ALU). **Henry Co.:** 1966/07/28, *Clark, R.C. 6141* (NCU). **Jackson Co.:** 1899/06/18, *Harbison, T.G.* (NCU). **Jefferson Co.:** 1899/06/02, *General 453* (A). **Lee Co.:** 1897/08/11, *Earle, F.S.* (MO). **Lowndes Co.:** 1982/10/03, *Gunn. S.C. 1366* (AUA). **Macon Co.:** 1969/04/29, *Freeman, J.D. 695* (AUA). **Marengo Co.:** 196?/06/05, *Clark, R.C. 13644* (NCU). **Marshall Co.:** 1977/04/23, *Ross, L. 107* (ALU). **Mobile Co.:** 1898/04/15, *Mohr, C.* (ALU). **Monroe Co.:** 1959/06/15, *Grelen, H.* (FLAS). **Montgomery Co.:** 1880/07/15, *Mohr, C.* (US). **Perry Co.:** 196?/08/10, *Clark, R.C. 17835* (NCU). **Pike Co.:** 1931/04/15, *Palmer, E.J. 38656* (MO). **Randolph Co.:** 1967/04/16, *Clark, R.C. 11365* (NCU). **St. Clair Co.:** 1951/06/24, *Hollis, C.G.* (ALU). **Sumpter Co.:** 1966/06/06, *Drapalik, D. 1362* (NCU). **Talladega Co.:** 1966/06/20, *Clark, R. and Heard, T.A. 2895* (NCU). **Tallapoosa Co.:** 1973/10/06, *Pringle, G. 072* (UNA). **Tuscaloosa Co.:** 1982/10/07, *Burckhalter, R. 015* (UNA). **Walker Co.:** 196?/05/08, *Clark, R.C. 12564* (NCU). **Winston Co.:** 196?/05/10, *Clark, R.C. 12995* (NCU). **ARKANSAS. Cleburne Co.:** 1967/09/06, *Demaree, D. 56271* (IBE). **Dallas Co.:** 1975/07/05, *Sparkman 69902* (IBE). **Faulkner Co.:** 1924/10/13, *Palmer, E.J. 26535* (A). **Fulton Co.:** 1909/05/21, *Bush, B.F. 5690* (A). **Garland Co.:** 1925/04/23, *Palmer, E.J. 26885* (A). **Howard Co.:** 1909/10/07, *Kellogg, J.H.* (A). **Independence Co.:** 1968/06/24, *Thomas, D. 9093* (NLU). **Izard Co.:** 1929/04/27, *Palmer, E.J. 35547* (A). **Marion Co.:** 1914/06/14, *Palmer, E.J. 5974* (A). **Ouachita Co.:** 1975/08/06, *Demaree, D. 69628* (IBE). **Pope Co.:** 1932/09/20, *Merrill, G. 36* (A). **Saline Co.:** 1972/07/15, *Demaree, D. 65241* (IBE). **Sharp Co.:** 1970/0?/24, *Thomas, D. 15255* (NLU). **Stone Co.:** 19?1/09/18, *Demaree, D. 64280* (IBE). **White Co.:** 1887/0?/23, *Coville, F.V. 171* (US). **DELAWARE. Kent Co.:** 1941/05/09, *Tatnall, R.R. 4836* (DOV). **New Castle Co.:** 1930/05/30, *Tatnall, R.R. 896* (DOV). **Sussex Co.:** 1902/09/12, *Norton, J.B.S.* (MARY). **District of Columbia:** 1889/05/18, *Burgess, E.S.* (MARY). **FLORIDA. Alachua Co.:** 1982/03/14, *Easterday, J.C. 821* (USF). **Clay Co.:** 1869/03, *Canby, W.M.* (US). **Columbia Co.:** 1895/07/11-19, *Nash, V.* (A). **Duval Co.:** 1894/07/09, *Curtiss, A.H. 4553* (US). **Escambia Co.:** 1949/04/15, *Hood, S.C. 1915* (FLAS). **Franklin Co.:** 1923/09/27, *Harbison, T.G. 6046* (A). **Gadsden Co.:** 1966/04/30, *McDaniel, S. 7407* (IBE). **Hamilton Co.:** 1900/04/17, *Hugar, A.* (MO). **Jackson Co.:** 1929/04/12, *Palmer, E.J. 35299* (US). **Jefferson Co.:** 1950/09/30, *Kruz, H.* (FSU). **Leon Co.:** 1920/10/06, *Harbison, T.G. 5?10* (A). **Liberty Co.:** 1957/05/10, *Uttal, J.L. 5382* (LYN). **Marion Co.:** 1985/07/18, *Hansen, B.F., Van Etten, M. and Wunderlin R.P. 9981* (JSF). **Polk Co.:** 1985/06/12, *Hopkins, S. 3410* (FLAS). **Union Co.:** 1939/08/18, *Murrill, W.A.* (FLAS). **Wakulla Co.:** 1964/06/21, *Godfrey, R.K. 64178* (FSU). **GEORGIA. Bartow Co.:** 1971/08/01, *Waters, J.C. 136* (AUA). **Berrien Co.:** 1973/05/06, *McCarty, T.* (MO). **Bibb Co.:** 1901/05/26, *No Collector* (MO). **Brooks Co.:** 1966/07/13, *Faircloth, W.R. 3465* (MO). **Burke Co.:** 1938/04/10, *McVaugh, R. and Byron, J.H. 2470* (GA). **Chatham Co.:** 1958/06/1?, *Duncan, W.H. 21113* (DHL). **Clarke Co.:** 1929/03/12, *Dunnaway, J.M. E7433* (GA). **Clay Co.:** 1966/0?/26, *Bozeman, J.R. 6614* (NCJ). **Cobb Co.:** 1943/05/02, *Wurdack, J.* (CM). **Decatur Co.:** 1900/06/20, *Sargent, C.S.* (A). **DeKalb Co.:** 1966/06/25, *Wood, A.* (GA). **Dougherty Co.:** 1900/08/13, *Maxon, W.R. and Pollard, C.L. 505* (US). **Echols Co.:** 1965/07/16, *Dean, R. and Faircloth, W.R. 2297* (GA). **Elbert Co.:** 19??/09/10, *Coile, N.C. 1424* (GA). **Floyd Co.:** 1956/08/09, *Lipps, L. 957* (TENN). **Glascock Co.:** 1966/07/15, *Faircloth, W.R. 3499* (MO). **Greene Co.:** 1939/08/13, *Duncan, W.H. 1585* (GA). **Gwinnett Co.:** 1908/04/12, *Allard, H.A. 106* (US). **Habersham Co.:** 1914/05/06, *Ashe, W.W.* (NCU). **Hancock Co.:** 1966/08/09, *Bozeman, J.R. 7314* (NCU). **Hart Co.:** 1942/04/26, *Duncan, W. 4846* (GAM). **Houston Co.:** 1979/06/01, *Dixon, D. 1409* (NLU). **Jackson Co.:** 1948/04/30, *Cronquist, A. 5085* (US). **Jones Co.:** 1966/08/08, *Bozeman, J.R. 7188* (NCU). **Lanier Co.:** 1965/07/30, *Faircloth, W.R. and Norsworthy, J. 2603* (NCU). **Liberty Co.:** 1916/09/09, *Harbison, T.G.* (A). **Lowndes Co.:** 19?3/05/17, *McCarty, T.* (MO). **Macon Co.:** 1898/10/02, *Canby, W.M., Muir, J. and Sargent, C.S.* (DOV). **Meriwether Co.:** 1945/04/17, *Henry, M.G. 3982* (GA). **Morgan Co.:** 1979/04/22, *Hill, L. W848* (GA). **Oglethorpe Co.:** 1968/05/04, *Montgomery, F. 1025* (GA). **Peach Co.:** 1966/07/02, *Clark, J.V.* (GA). **Putnam Co.:** 1942/04/30, *Duncan, W.H. 4913* (GA). **Rabun Co.:** 1893/08/07, *Small, J.K.* (MO). **Richmond Co.:** 1900/04/25, *Cuthbert, A. 11* (DOV). **Screven Co.: 1948**/04/17, *Cronquist, A. 5004* (GA). **Stephens Co.:** 1975/07/21, *Boufford, D.E. and Wood, E.W. 2096* (NCU). **Sumpter Co.:** 1940/05/11, *Duncan, W.H. 2342* (GH). **Troup Co.:** 1829/06/12, *Sargent, C.S.* (A). **Turner Co.:** 1947/11/05, *Thorne, R.F. 7509* (GA). **Washington Co.:** 19?0/06/26, *Hobbs, G.B. and Lipscomb, H. 52* (NCU). **ILLINOIS. Wabash Co.:** 1875, *Schneck, D.* (MO). **KENTUCKY. Boyd Co.:** 1923/05/20, *Horsey, R.E. 1662* (A). **Pulaski Co.:** 1939/09/08,

Brown, E. L. 2637 (A). **LOUISIANA. Bienville Parish:** 1967/06/07, *Thieret, J.W. 26568* (LAF). **Caddo Parish:** 1969/06/15, *Thieret, J.W. 31277* (LAF). **Caldwell Parish:** 1973/06/02, *Marx, P. et al 1207* (NLU). **Claiborne Parish:** 1975/04/26, *Haynes, R. R. 4807* (ALU). **Desoto Parish:** 1979/11/10, *Dixon, D. 2526* (NLU). **Morehouse Parish:** 1972/05/04, *Thomas, D.R. 28684* (NLU). **Orleans Parish:** 1916/04, *Cocks, R.S.* (NO). **Rapides Parish:** 1976/06/18, *Shultz, C.J. and S.E. 142* (NLU). **Tangipohoa Parish:** 1901/09/01, *Cocks, R.S.* (NO). **Union Parish:** 1983/07/23, *Moore, D.C. 1670* (NLU). **MARYLAND. Allegany Co.:** 1940/06/12, *Norton, J.B.S.* (MARY). **Caroline Co.:** 1928/06/03, *Tatnall, R.R. 78* (DOV). **Montgomery Co.:** 1918/09/29, *Hunnewell, F.W. 5661* (GH). **Washington Co.:** 1906/07/11, *Jones, W.R. and Shreve, F. 689* (US). **Wicomico Co.:** 1903/06/06, *Norton, J.B.S.* (MARY). **Worcester Co.:** 1940/06/24, *Jeffery, W.F. and Norton, J.B.S.* (MARY). **MISSISSIPPI. Clarke Co.:** 1967/09/09, *Jones, S.B. and Jones, C. 15241* (NCU). **Jasper Co.:** 1961/08/20, *McDaniel, S. 2689* (IBE). **Jones Co.:** 1978/06/03, *Morgan, D. 678* (IBE). **Kemper Co.:** 1859/05/01, *Holgand, E.* (MO). **Lauderdale Co.:** 1922/04/18, *Harbison, T.G. 6043* (A). **Lowndes Co.:** 1973/05/02, *Holmes, W.C. 1701* (NATC). **Newton Co.:** 1961/07/22, *McDaniel, S. 262 1* (IBE). **Wayne Co.:** 1967/04/12, *Bass, C., Jones, S.B., Prescott, V. and Reynolds, J.D. 11631* (GA). **MISSOURI. Carter Co.:** 1893/05/16, *Eggert, H.* (MO). **Dent Co.:** 1927/09/06, *Kellogg, J.* (MO). **Douglas Co.:** 1934/08/19, *Steyermark, J. 14705* (MO). **Ozark Co.:** 1928/06/28, *Palmer, E.J. 34812* (GH). **Reynolds Co.:** 1934/09/28, *Steyermark, J. A. 15577* (MO). **Shannon Co.:** 1978/05/18, *Summers, B. 396* (MO). **St. Louis Co.:** 1879/09/16, *Engelman, G.* (MO). **Texas Co.:** 1934/08/15, *Steyermark, J.A. 14530* (MO). **Wayne Co.:** 1893/06/22, *Eggert, H. 5335* (CM). **NEW JERSEY. Burlington Co.:** 1955/08/18, *Churchill, J.A.* (MSC). **Cape May Co.:** 1917/07/15, *Killip, E.P. 2406* (US). **Cumberland Co.:** 1964/07/27, *Gillis, W.T. 5646* (MSC). **Monmouth Co.:** 1976/06/24, *Schwenk, J.* (MO). **Salem Co.:** 1874/07/04, *Redfield, J.H. 1902* (MO). **NEW YORK. Cattaraugus Co.:** 1895/07/17, *Andrews, E.F.* (AUA). **Richmond Co.:** 1879/08/22, *Schrenk, J.* (MO). **Suffolk Co.:** 1879/06/03, *LSK* (MO). **NORTH CAROLINA. Alamance Co.:** 1956/09/29, *Hammond, A.E. and Ramseur, G.S. 2254* (NCU). **Alexander Co.:** 1935/05/08, *Verrhoof, O.* (NCSC). **Anson Co.:** 1956/09/21, *Ahles, H.E. and Leisner, R.S. 19469* (NCU). **Bladen Co.:** 1948/06/10, *Fox, W.B. et al 1705* (NCSU). **Brunswick Co.:** 1954/08/01, *Melvin, L.* (NCU). **Buncombe Co.:** 1908/09/15, *Eggleston, W.W. 4129* (US). **Burke Co.:** 1958/09/09, *Bell, R.C. 15054* (NCU). **Carteret Co.:** 1923/06/30, *Holmes, J.S.* (NCU). **Caswell Co.:** 1958/05/22, *Bell, R.C. 11893* (NCU). **Catawba Co.:** 1891/06/25, *Heller, A.A. and Small, J.K.* (US). **Chatham Co.:** 1988/05/19, *Swab, E.C. 162* (USCH). **Chowan Co.:** 1898/07/29, *Kearney, T. Jr. 1903* (US). **Cleveland Co.:** 1956/06/22, *Ahles, H.E. and Leisner, R.S. 15253* (NCU). **Craven Co.:** 1919/05/26, Harbison, T.G. 15090 (NCU). **Cumberland Co.:** 1957/05/04, *Ahles, H.E. and Hammond, A. 24389* (NCU). **Davidson Co.:** 1916/06/07, *Totten, H.R.* (NCU). **Davie Co.:** 1916/06/08, *Totten, H.R.* (NCU). **Durham Co.:** 1932/08/02, *Blomquist, H.L. 183* (US). **Forsyth Co.:** 1948/09/07, *Correll, D.S. and Correll, H.B. 14478* (DUKE). **Franklin Co.:** 1956/07/10, *Ahles, H.E. and Leisner, R.S. 16508* (NCU). **Gaston Co.:** 1956/09/17, *Ahles, H.E. and Leisner, R.S. 18810* (NCU). **Granville Co.:** 1956/05/22, *Ahles, H.E. and Bell, C.R. 12756* (NCU). **Greene Co.:** 1934/05/12, *Totten, H.R.* (NCU). **Guildford Co.:** 1953/05/12, *Melvin, L.* (NCU). **Halifax Co.:** 1956/07/19, *Ahles, H.E. and Leisner, R.S. 16975* (NCU). **Harnett Co.:** 1956/09/29, *Laing, H. 349* (NCU). **Henderson Co.:** 1962/08/21, *Pittillo, D. 546* (GA). **Hertford Co.:** 1958/07/08, *Ahles, H.E. and Duke, J.A. 46018* (NCU). **Iredell Co.:** 1958/05/18, *Ahles, H.E. and Britt, R. 41050* (NCU). **Jackson Co.:** 1940/07/15, *Totten, H.R.* (NCU). **Johnston Co.:** 1919/04/26, *Harbison, T.G. 14967* (NCU). **Jones Co.:** 1954/08/08, *Corbin and Wyatt* (NCU). **Lee Co.:** 1955/06/27, *Kessler, P.-A. 350* (NCU). **Lenoir Co.:** 1908/10/12, *Eggleston, W.W. 4279* (US). **Lincoln Co.:** 1957/06/11, *Bell, R.C. 8907* (NCU). **Madison Co.:** 1908/09/21, *Eggleston, W.W. 4158* (CM). **Mecklenburg Co.:** 1958/10/02, *Ahles, H.E. and Duke, J.A. 49968* (NCU). **Montgomery Co.:** 1970/05/18, *Wells, E.F. 2888* (NCU). **Moore Co.:** 1900/08/20, *Ashe, W.W.* (CM). **New Hanover Co.:** 1963/06/30, *Ahles, H.E. and McCrary, A. 537* (NCU). **Northampton Co.:** 1958/07/07, *Ahles, H.E. and Duke, J.A. 45726* (NCU). **Orange Co.:** 1969/08/08, *Whigham, D. 1251* (NCU). **Person Co.:** 1951/07/31, *Batson, W.T. Jr. 749* (DUKE). **Pitt Co.:** 1956/05/09, *Eason, M. 20* (NCU). **Polk Co.:** 1921/08/11, *Peattie, D.C. 1163* (NCU). **Randolph Co.:** 1965/10/10, *Harper, F.H. and Harper, J.S. 4187* (NCU). **Rockingham Co.:** 1956/07/07, *Radford, A.E. 13628* (NCU). **Rowan Co.:** 1908/09/12, *Eggleston, W.W. 4105* (CM). **Rutherford Co.:** 1956/08/30, *Melvin, L. 5007* (NCU). **Scotland Co.:** 1937/05/03, *Coker, W.C.* (NCU). **Stanly Co.:** 1891/08/18, *Heller, A.A. and*

Small, J.K. 49 (MO). **Stokes Co.:** 1958/07/26, *Radford, A.E. 37727* (NCU). **Transylvania Co.:** 1961/07/05, *Rodgers, C.L. 61328* (DUKE). **Vance Co.:** 1956/10/01, *Ahles, H.E. and Leisner, R.S. 20430* (NCU). **Wake Co.:** 1964/07/14, *Sawyer, G.P. Jr. 1256* (USCH). **Warren Co.:** 1968/06/12, *O'Briant, S. and Radford, A.E. 45482* (ALU). **Washington Co.:** 1958/06/15, *Radford, A.E. 35225* (NCU). **Wayne Co.:** 1957/05/03, *Radford, A.E. 22009* (NCU). **Wilkes Co.:** 1938/06/13, *Stewart, S.C. and Stewart, L.* (NCU). **OKLAHOMA. Choctaw Co.:** 1850s-1900s, *Edwards, J.E.* (GH). **Garrett Co.:** 1905/06/08, *Shreve, F. 483* (US). **Marshall Co.:** 1963/06/19, *Ware, G.* (NATC). **Pusmataha Co.:** 1931/05/26, *Palmer, E.J. 39406* (MO). **PENNSYLVANIA. Clinton Co.:** 1895/06/10, *Glatfelter, N.M.* (MO). **Delaware Co.:** 1903/05/20, *Graves, J.A.* (MO). **North Hampton Co.:** 1891/08/03, *Porter, T.C.* (US). **SOUTH CAROLINA. Abbeville Co.:** 1957/06/29, *Radford, A.E. 25986* (NCU). **Aiken Co.:** 1898/08/06, *Eggert, H.* (MO). **Allendale Co.:** 1953/04/06, *Batson, W.T. and Kelley, W.R.* (USCH). **Anderson Co.:** 1809/07/24, *Davis, J.* (CM). **Barnwell Co.:** 1952/06/13, *Batson, W.T. and Kelley, W.R.* (USCH). **Beaufort Co.:** 1917/04/29, *Churchill, J.R.* (MO). **Calhoun Co.:** 1957/05/19, *Ahles, H.E. and Haesloop, J.G. 25520* (NCU). **Charleston Co.:** 1957/05/20, *Ahles, H.E. and Haesloop, J.G. 25769* (NCU). **Cherokee Co.:** 1957/09/18, *Ahles, H.E. 34428* (TENN). **Chester Co.:** 1957/06/27, *Bell, R.C. 9536* (NCU). **Clarendon Co.:** 1914/05/22, *Stone, W. 271* (A). **Colleton Co.:** 1983/04/04, *Rayner, D.A. 1593* (USCH). **Darlington Co.:** 1941/05/15, *Smith, B.E. 947* (USCH). **Edgefield Co.:** 1957/05/12, *Radford, A.E. 22648* (NCU). **Fairfield Co.:** 1983/06/22, *Gould, B., LaBorde, O. and Pugh, A.E.* (NLU). **Florence Co.:** 1982/04/24, *McFarlane, B. 1191* (USCH). **Greenville Co.:** 1934/09/20, *Wherry, E.T.* (A). **Horry Co.:** 1957/09/12, *Totten, H.R. 1576* (DHL). **Jasper Co.:** 1954/04/19, *Ahles, H.E. 7807* (NCU). **Kershaw Co.:** 1960/05/25, *Herring, W.A. 3* (USCH). **Lancaster Co.:** 1975/05/10, *Boufford, D.E. 15999* (CM). **Laurens Co.:** 1991/07/09, *Horn, C.N. and Mytko, D.E. 4564* (USCH). **Lee Co.:** 1957/06/06, *Radford, A.E. 24320* (NCU). **Lexington Co.:** 1934/05/19, *Palmer, E.J. 42423* (MO). **McCormick Co.:** 1960/10/14, *Mc Comb, C. 65* (GA). **Newberry Co.:** 1957/06/25, *Bell, R.C. 9186* (NCU). **Oconee Co.:** 1942/05/09, *Prince, A.E. 4001* (A). **Orangeburg Co.:** 1983/05/23, *Aulbach-Smith, C.A., Long, G. and Tallevast, T. 2476* (USCH). **Pickens Co.:** 1975/07/18, *Boufford, D.E. and Wood, E.W. 2077* (NCU). **Richland Co.:** 1976/08/26, *Nelson, J.B. 681* (IBE). **Spartanburg Co.:** 1957/06/04, *Bell, R.C. 8169* (NCU). **Sumpter Co.:** 1933/04/17, *Harbison, T.G. and Totten, H.R.* (NCU). **Union Co.:** 1993/05/09, *Horn, C.N. 6627* (USCH). **Williamsburg Co.:** 1957/06/12, *Radford, A.E. 24830* (NCU). **York Co.:** 1957/06/05, *Ahles, H.E. and Haesloop, J.G. 27098* (NCU). **TENNESSEE. Anderson Co.:** 1961/06/30, *Ellis, W.H. 28599* (TENN). **Cocke Co.:** 1898/07, *Ruth, A. 286* (US). **Hamilton Co.:** 1921/04, *Beckwith, F. 1024* (US). **Knox Co.:** 1938/06/29, *Sharp, A.J. 232* (TENN). **Lawrence Co.:** 1898/07/18, *Ruth, A. 294* (MO). **Union Co.:** 1934/07/10, *Kelly 2473* (TENN). **TEXAS. Bell Co.:** 1902/05/08, *Reverchon, J.* (MO). **Jasper Co.:** 1963/04/14, *Correll, D.S. and Correll, H.B. 27229* (MO). **Smith Co.:** 1949/05/15, *Shinners, J.H. 11183* (GA). **VIRGINIA. Alleghany Co.:** 1909/05/19, *Eggleston, W.W. 4374* (MO). **Amelia Co.:** 1937/05/25, *Lewis, J.B. 555* (VPI). **Amherst Co.:** 1969/10/01, *Crandell, D. 9669* (LYN). **Appomatox Co.:** 1967/07/07, *James, F.C. 7231* (NCU). **Bedford Co.:** 1871/08, *Curtiss, A.H.* (GH). **Botetourt Co.:** 1967/05/06, *James, F.C.* (NCU). **Brunswick Co.:** 1968/04/21, *James, F.C. 13252* (NCU). **Buckingham Co.:** 1951/06/29, *Jarrett, G.P and Little, R.L. 14622* (US). **Campbell Co.:** 1893/07/20, *Heller, A. 1099* (MO). **Caroline Co.:** 1968/04/28, *James, F.C. 13895* (NCU). **Chesterfield Co.:** 1971/06/10, *Johnson, M.F. 23220* (NCU). **Craig Co.:** 1967/07/19, *James, F.C. 7630* (NCU). **Dinwiddie Co.:** 1965/08/18, *James, F.C. 2375* (NCU). **Fairfax Co.:** 1970/07/31, *Kiltz, B.F. 57* (NLU). **Fluvanna Co.:** 1921/06/03, *Eggleston, W.W. 17740* (US). **Franklin Co.:** 1966/07/15, *Ramsey, G.W. et al 4938* (LYN). **Frederick Co.:** 1941/06/19, *Palmer, E.J. 45271* (A). **Giles Co.:** 1935/09/07, *Adams, J.W. and Wherry E. 2323* (A). **Goochland Co.:** 1970/05/28, *Johnson, M.F. 3204* (VCU). **Greensville Co.:** 1944/06/22, *Fernald, M.L. and Lewis, J.B. 14609* (US). **Hanover Co.:** 1968/04/26, *James, F.C. 13446* (NCU). **Henry Co.:** 1968/05/28, *James, F.C. 10443* (NCU). **Lee Co.:** 1968/05/17, *James, F.C. 9791* (NCU). **Louisa Co.:** 1934/07/09, *Sharp, A.J. 1102* (TENN). **Lunenburg Co.:** 1965/09/19, *James, F.C. 3071* (NCU). **Mathews Co.:** 1852/05, *Bischoff, G.G.* (MO). **Mecklenburg Co.:** 1966/07/08, *Seaman, W.D. 3739* (NCU). **Middlesex Co.:** 1966/07/14, *James, F.C.* (NCU). **Montgomery Co.:** 1962/07/02, *Kral, R. 14818* (FSU). **New Kent Co.:** 1977/05/12, *Bims, S.* (VCU). **Patrick Co.:** 1950/07/24, *Mikula, B. 6813* (WILLI). **Pittsylvania Co.:** 1893/07/30, *Heller, A. 1099* (A). **Powhatan Co.:** 1967/06/08, *James, F.C. 6279* (NCU). **Prince George Co.:** 1936/06/19, *Fernald, M.L. et al 5791* (GH). **Roanoke Co.:** 1969/07/

29, *Uttal, L.J. 6648* (VPI). **Rockbridge Co.:** 1881/05, *J.R.C.* (MO). **Rockingham Co.:** 1956/07/01, *Allard, H.A. 21957* (US). **Shenandoah Co.:** 1970/05/19, *Churchill, J.A.* (MSC). **Smyth Co.:** 1892/06/20, *Small, J.K.* (US). Suffolk City, 1980/09/17, *Wieboldt, T.F. 590* (WILLI). **Surry Co.:** 1934/08/17, *Totten, H.R.* (NCU). **Zuni Co.:** 1908/08/19, *Render, A.* (A). **WEST VIRGINIA. Grant Co.:** 1979/05/15, *Duppstadt, H. 029* (WVA). **Greenbrier Co.:** 1959/07/29, *Clarkson, R.B. 2992* (NCU). **Hampshire Co.:** 1929/05/30, *Walker, E.H. 303* (GA). **Hardy Co.:** 1955/06/16, *Bartley, F. and Hicks, L.E. 2122* (NY). **Mineral Co.:** 1928/10/06, *Eggleston, W.W. & Kelly, J.W. 22859* (US). **Morgan Co.:** 1969/05/10, *Downs, R.M. 6349* (NCU). **Wyoming Co.:** 1900/08/13, *Morris, E.L. 1189* (US).

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Book Reviews

Shatoiya De La Tour and Richard De La Tour. 2001. **The Herbalist's Garden: A Guided Tour of 10 Exceptional Herb Gardens: The People Who Grow Them and the Plants That Inspire Them.** (ISBN 1-58017-410-8, hbk.). Storey Publishing, 210 MASS MoCA Way, North Adams, MA, 01247. U.S.A. (**Orders:** # 67410, 1-800-441-5700; www.storey.com). $27.50, 229 pp., color photos, color illustrations, 8 3/8" × 10".

Herbalists and gardeners (or both) will enjoy this very readable coffee table-style book. The authors are a husband-and-wife team of passionate medicinal plant gardeners who also run an herb store. This book is a tour of the gardens of ten well known herbal medicine experts, including James Duke, Rosemary Gladstar, and others. Each section includes the biographies of the gardeners and the history behind their gardens. The copious color photographs allow one to really step inside these calm retreats. A particular gem is the section on James Duke's "farmette" in Maryland. A renowned ethnobotanist and researcher, Dr. Duke's six-acre herb garden includes 80 plots, each centered on a specific health condition, such as cancer or respiratory conditions. Included in each section are lists of the gardeners' favorite plants, watercolor garden plans, medicinal tea recipes, and tips for growing your own medicinal plants.—*Marissa Oppel, MS, Herbarium Technician, Botanical Research Institute of Texas, Fort Worth, Texas 76102-4060, U.S.A.*

Londa Schiebinger. 2004. **Plants and Empire: Colonial Bioprospecting in the Atlantic World** (ISBN 0-674-01487-1, hbk.). Harvard University Press, 79 Garden Street, Cambridge, MA 02138, U.S.A. (**Orders:** www.hup.harvard.edu/index.html). $39.95, 320 pp., 20 black-and-white illustrations, 6 1/2" × 9 1/2".

This page-turner is a fascinating glimpse into the world of colonial bioprospecting during the "long eighteenth century." When botany was young, voyaging botanists and their assistants collected plants from the New World in a mad race to discover the most economically and medicinally useful plants. Colonial bioprospecting was a cut throat business involving botanical spies and pirates. The author presents an overview of this rough-and-tumble era, focusing on the voyaging botanists and those armchair botanists who stayed in Europe and had their plants collected by assistants, ship captains, and others. A botanical artist and scientist, Maria Sibylla Merian, was one of very female voyaging botanists during this time period. While in the Caribbean, Merian described the "peacock flower" and its use by slave women as an abortifascient. Schiebinger's carefully constructed history of this discovery and the reasons it never reached mainstream Europeans is an interesting portrait of European reproductive mores and the business of botany in the 1700s.—*Marissa Oppel, MS, Herbarium Technician, Botanical Research Institute of Texas, Fort Worth, Texas 76102-4060, U.S.A.*

A NEW SPECIES OF *STENANTHIUM* (MELANTHIACEAE) FROM TENNESSEE, U.S.A.

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ABSTRACT

Stenanthium diffusum Wofford, sp. nov., is described as a new species from Fentress, Morgan, Pickett, and Scott counties on the northern Cumberland Plateau of Tennessee. It is most closely related to *S. gramineum* but differs in having (1) a more diffuse inflorescence, (2) flowers on the mid-portion of lateral panicle branches spaced ≥8 mm apart and with distinct pedicels (1.6–4 mm long), and (3) the uppermost non-bracteal stem leaf less than 15 cm above ground level. It also flowers later and has ecological requirements differing significantly from *S. gramineum*. *Stenanthium diffusum* is an extremely rare rockhouse endemic in need of consideration for state and federal endangered species status.

RESUMEN

Se describe una nueva especie *Stenanthium diffusum* Wofford, sp. nov., de los condados de Fentress, Morgan, Pickett, y Scott del norte del Cumberland Plateau de Tennessee. Está estrechamente relacionada con *S. gramineum* pero difiere por tener (1) una inflorescencia más difusa, (2) flores en la parte media lateral de las ramas del panículo espaciadas ≥8 mm y con pedicelos diferenciados (1.6–4 mm de longitud), y (3) la hoja superior del tallo no bracteal a menos de 15 cm sobre el nivel del suelo. También florece más tarde y tiene requerimientos ecológicos que difieren bastante de *S. gramineum*. *Stenanthium diffusum* es un endemismo extremadamente raro de roquedos que requiere el estatus de especie amenazada estatal y federalmente.

TAXONOMIC/NOMENCLATURAL PERSPECTIVE

In the traditional sense, the genus *Stenanthium* (Liliaceae s.l.) is represented by one species in Asia, *S. sachalinensis* F. Schmidt, and from two to four taxa in North America. *Stenanthium occidentale* A. Gray, western featherbell, occurs in California, Oregon, Washington, Idaho, Montana, British Columbia, and Alberta (USDA, NRCS). In the eastern United States, depending upon taxonomic interpretation, *Stenanthium* may be composed of the typical variety, *S. gramineum* (Ker Gawler) Morong var. *gramineum* (eastern featherbell), and two additional varieties, *S. gramineum* var. *micranthum* Fernald and *S. gramineum* var. *robustum* (S. Watson) Fernald. *Stenanthium gramineum* s.l. ranges from Florida to Texas and northward to Indiana and Pennsylvania. Local established waifs are known from upper Michigan (Voss 1972).

Fernald (1946) provided a treatment of the *Stenanthium gramineum* complex in the eastern United States and concluded that there is a confluent series

of variation and that ... "As the best I can now do I propose the following definition of the three varieties." Although it is my impression that he had little faith in their distinctiveness, he did provide the following key for others to compare with their collections:

a. Stem (dry) 4–10 mm thick at lowest exposed internode; leaves rather crowded below, rapidly diminishing below panicle, firm to coriaceous, mostly opaque, the larger ones 4–15 mm wide, their prominently raised ribs producing a corrugated surface; panicle lax, the branches distant, the flowers mostly subremote along the often flexuous branches; perianth 3–8(–10) mm long; capsules ovoid-urceolate, 6–9 mm long, on spreading to reflexed pedicels; seeds 5–5.5 mm long.

Stem 0.5–1.9 m high, 4–10 mm thick at base; perianth 5–10 mm long _____ *S. gramineum* var. *typicum* (= var. *gramineum*)

Stem 0.25–1 m high, 1.5–5 mm. thick at the base; perianth 3–4(-5) mm long _____ var. *micranthum*

a. Stem (dry) 7–15 mm thick at lowest exposed internode, up to 1.8 m high; leaves crowded and numerous nearly up to panicle, thin and membranaceous, translucent, the larger ones 1–3 cm wide, their ribs mostly immersed in the tissue; panicle usually dense, with flowers crowded along the stiffly ascending branches; perianth 5–10 mm long; capsules oblong-subcylindric, 9–10 mm long, crowded and ascending to horizontally spreading; seeds 5–8 mm long _____ var. *robustum*

Since Fernald's (1946) assessment, the two varieties of typical *S. gramineum* have been largely unrecognized as distinct taxa in local and regional floras of the eastern United States as well as in the recent Flora of North America treatment by Utech (2002). Utech also cited and agreed with Gates (1918) and Johnson (1969) that the varieties of *S. gramineum* are indistinct and sympatric. I agree that significant morphological variation and overlap of characters exist but the extremes, however, are strikingly distinct and warrant consideration for additional study.

Recently, Zomlefer and Judd (2002) made the following significant new combinations in the tribe Melanthieae based on parsimony analysis of ITS and *trn*L-F DNA sequence data, distributions, chromosome numbers, and morphological data: *Stenanthium sachalinensis* = *Anticlea sachalinensis* (F. Schmidt) Zomlefer & Judd, *Stenanthium occidentale* = *Anticlea occidentalis* (A. Gray) Zomlefer & Judd, *Zigadenus densus* (Desr.) Fernald = *Stenanthium densum* (Desr.) Zomlefer & Judd, and *Zigadenus leimanthoides* A. Gray = *Stenanthium leimanthoides* (A. Gray) Zomlefer & Judd. These former *Zigadenus* taxa share significant morphological and geographical distinctions from the *S. gramineum* complex and their transfer to *Stenanthium* may be subject to debate by botanists emphasizing morphology and biogeography. Both *Zigadenus densus* and the poorly defined and taxonomically ambiguous *Z. leimanthoides* have a small gland at the base of the obovate, round-tipped tepals. They are primarily restricted to the southeastern U. S. Coastal Plain with the exception of a few outliers in the mountains of West Virginia, Virginia, and North Carolina, and on the Eastern Highland Rim of Tennessee. *Stenanthium gramineum* and *S.*

diffusum lack a gland at the base of the lanceolate, tortuose-tipped tepals. *Stenanthium gramineum* is widespread throughout most of the eastern U.S. while *S. diffusum* is restricted to the northern Cumberland Plateau of Tennessee. Conversely, adoption of the new combinations of Zomlefer and Judd would leave the genus *Stenanthium* s.s. restricted to the eastern United States.

BIOLOGICAL/ECOLOGICAL/FLORISTIC RELATIONSHIPS

The Cumberland Plateau is perhaps the most floristically diverse physiographic province in Tennessee, as shown in a recent treatment of the woody plants of Tennessee (Wofford & Chester 2002). This treatment exemplifies that the Cumberland Plateau has both more native genera and native species (and lesser taxa) than any other physiographic province in the state and surprisingly a few more than the Blue Ridge which includes the Tennessee portion of the Great Smoky Mountains National Park and numerous other high mountain peaks.

The highly dissected northern portion of the Cumberland Plateau in Tennessee (Fentress, Morgan, Scott, and Pickett counties) and Kentucky (McCreary Co.) has a unique habitat commonly referred to as rockhouses. These are amphitheater-like semicircular recessions under overhangs and ledges of Pennsylvanian sandstone. In addition to providing moist, sandy soil, other physical features unique to this habitat include lower light quality, lower summer and higher winter temperatures, higher relative humidity, and lower evaporation rates. Rare and/or unique taxa occur here at or behind the drip line and are only rarely in direct sunlight or rainfall. The flowering plant taxa of interest often have paler, more delicate leaves that probably would not withstand direct sunlight or heavy rainfall [see Walck et al. (1986) for an excellent review of sandstone rockhouses with emphasis on ecology and evolution of endemic taxa].

Several taxa closely related (with an asterisk) to Tennessee rockhouse endemics are often common in adjacent forests or outcrops. Examples of these sister species pairs are: *Thalictrum clavatum* DC.* and *T. mirable* Small, *Arenaria glabra* Michx.* and *A. cumberlandensis* Wofford & Kral, *Ageratina altissima* (L.) King & H.E. Robins.* and *A. luciae-brauniae* (Fern.) King & H.E. Robins., *Silene viginica* L.* and *S. rotundifolia* Nutt., and *Heuchera villosa* Michx.* and *H. parviflora* Bartl. In addition, three pteridophyte taxa endemic to sandstone rockhouses in the eastern U. S. occur on both the Cumberland Plateau and Blue Ridge provinces of Tennessee (Walck 1986); these are: *Vittaria appalachiana* Mickel & Farrar, *Trichomanes intricatum* Farrar, and *Trichomanes boschianum* Sturm. The only rockhouse endemic that is also a Tennessee endemic is the herein described new species of *Stenanthium*.

SPECIES DESCRIPTION

Field observations for numerous seasons from Cumberland Plateau rockhouses have resulted in the discovery of yet another undescribed rockhouse endemic.

This new taxon is most closely related to *S. gramineum* but the distinct differences in morphology, restricted distribution, phenology, associated taxa, and habitat requirements warrant recognition and description of a new species of *Stenanthium*, to wit:

Stenanthium diffusum Wofford, sp. nov. (**Figs. 1, 2, 4**). TYPE: TENNESSEE. Pickett Co.: Pickett State Park, beneath and at the margin of rockhouse ledges and overhangs on Ladder Trail at crossing of Thompson's Creek, 36°33'18"N, 84°47'55"W, elev. 1597 ft, 23 Sep 2005, *B.E. Wofford 20051, with D.K. Smith, G. Bresowar, & S. Huskins* (HOLOTYPE: TENN; ISOTYPES: BRIT, GH, MO, NCU, NY, US).

Stenanthio gramineo arcte affinis sed differt inflorescentia magis diffusa, floribus midportione ramis lateralibus panicula ca. 1 cm separatim dispositis ac in pedicellis distinctis 3–4 mm longis portatis, et folio caulino nonbracteali summo minus quam 15 cm supra planitiem.

Plants glabrous perennial herbs with a single stem up to 1 m tall, mostly shorter, arising from a shallow seated tunicate bulb 2–8 cm deep; the bulb 2 cm high, 1 cm wide on reproductive individuals and surrounded by a dark, fibrous network of remains of previous years' leaf bases. **Roots** fibrous, numerous, up to 1 mm wide. **Leaves** 7–10, linear, entire, up to 3 dm long, 1–3(–4) cm wide, apex acute to slightly rounded, sheathing, predominately basal, only 1 or 2 above the basal rosette, conduplicate basally, reflexed and flattened distally, lowermost leaves often reclining; basal and cauline leaves (non-bracteal leaves) 15 cm or less above ground level, bracteal leaves becoming progressively reduced toward the inflorescence axes. **Inflorescence** a terminal, bracteate, diffuse panicle up to 3 dm wide of nodding, simple or compound racemes, the terminal portion racemose, erect, and up to 1.5 dm long or mostly shorter or absent, at least not longer than the lateral racemes; lateral branches 6–10, up to 15 in larger plants, each subtended by a bracteal leaf that becomes smaller toward the stem apex, axis of lateral branches up to 1.5 dm long. **Flowers** numerous, mostly bisexual or with the lowermost functionally staminate and the uppermost functionally pistillate, distinctly pedicellate, those on the mid-portion of panicle branches (5–)8–15(–18) mm apart and on slender pedicels (1–)1.6–4(–5) mm long, those of the terminal raceme, if present, of similar length; ultimate pedicel bracts 1.3 mm long, pale margined, clasping at the base. Tepals 6, spreading to slightly campanulate, scarcely connate basally, imbricate, narrowly lanceolate, apex acute to acuminate, tortuous, white at anthesis with a pale green midrib, becoming green and white margined with fruit development, persistent; sepals 4.5 mm long, 1.2 mm wide; petals 5 mm long, 1 mm wide, slightly narrower and longer than the sepals, scarcely tumid along the basal margins but not glandular or nectariferous. Stamens 6, in two series, antitepalous, scarcely epitepalous; filaments white, 0.7 mm long, recurved; anthers 1-locular, yellow, 0.4 mm long and wide, reniform, basifixed, extrorse; dehiscing into a peltate, dumbbell shaped disc; pollen yellow, ellipsoid. Gynoecium 3-carpellate, syncarpous, placentation axile; ovary about one-third inferior, white, 1 mm long, becoming green and glaucous



FIG. 1. Holotype of *Stenanthium diffusum* (*Wofford 20051*, TENN).

with fruit development, ovules up to 12, most aborting; styles 3, recurved, 0.4 mm long, persistent. **Fruit** a glaucous capsule 7–9 mm long, 3–4 mm wide; styles persistent and recurved; dehiscence septicidal; seeds fusiform, sometimes flattened on one side due to compression, 1–6/locule, 3–3.5 mm long, 1 mm wide, brown, with irregular wrinkles, flattened and slightly arcuate at the tip.

Habitat, distribution, and phenology.—*Stenanthium diffusum* is restricted to sandy, moist soil on ledges and below rockhouse overhangs on the northern Cumberland Plateau of Tennessee (Fig. 5). It is presently documented from only five populations in Morgan, Fentress, Pickett, and Scott counties (Fig. 6). The largest are found in Pickett State Park where they are associated with rockhouse endemics *Silene rotundifolia, Heuchera parviflora, Vittaria appalachiana* and the federally endangered *Arenaria cumberlandensis*. It flowers from mid-September to early October with fruits maturing in mid-November.

Additional collections examined. **TENNESSEE. Fentress Co.:** ca. 6 mi S Pickett Park, shaded rockhouse ledges, sandstone, 6 Sep 1978, *R. Kral 62661* (MO & VDB, as photocopy!); Twin Arches, 13 Oct 1978, *D. Eagar s.n.* (VDB, as photocopy!)*. **Morgan Co.:** beneath sandstone ledges at crossing of Tennessee Valley Authority transmission line above tributary to Clear Fork River, 36°18'59"N, 84°46'46"W, elev. ca. 1300 ft, 3 Oct 2005, *B.E. Wofford 20053, with D.K. Smith & G. Sexton* (TENN). **Pickett Co.:** acid sandy oak-pine woods above Thompsons Creek ca. 1 mi N Park Headquarters, 7 Jul 1973, *R. Kral 50563*; in sand of rockhouse, Hidden Passage, Pickett State Park, 13 Aug 1973, *A.J. Sharp s.n.* (TENN); Sharp Place Quad., Pickett State Park, Ladder Trail, series of sandstone rockhouses near Hwy. 154, in damp soil of sandstone rockhouse overhangs, with hemlock, near *Arenaria cumberlandensis*, 07 Aug 1993, *Milo Pyne 93-204* (TENN, VDB, as photocopy!); moist sandstone ledges in hemlock-white pine forest above Ladders Trail, Pickett Park, 22 Sep 1974, *R. Kral 54288* (MO & VDB, as photocopy!); Pickett State Park, rockhouse on Hidden Passage Trail, ca. 100 yards E of its jct. with Group Camp Trail, 36°33'35"N, 84°47'26"W, elev. 1538 ft, 26 Oct 2005, *B.E. Wofford 20054, with G. Sexton, D. Estes, & J. Beck* (TENN). **Scott Co.:** in moist, sandy soil at base of sandstone bluffs at Twin Arches, ca. 0.2 mi. w of Charit Creek, 36°32'30"N, 84°44'09"W, 26 Oct 2005, *B.E. Wofford 20052, with D.K. Smith, G. Bresowar, & S. Huskins* (TENN). *The correct county for this specimen is Scott Co.

DISCUSSION

Stenanthium diffusum is easily distinguished from *S. gramineum* by morphology, geography, phenology, and habitat (Table 1). Morphologically, the most apparent difference between these two taxa is the nature of the inflorescence. The inflorescence of *S. diffusum* is broader, up to 3 dm wide, more diffuse, and the terminal, wand-like raceme is absent or nearly absent (Fig. 2). The diffuse nature of the inflorescence of *S. diffusum* is due to the more numerous and longer secondary panicle branches that usually exceed 3 cm in length. In *S. gramineum* the inflorescence is less diffuse and rarely exceeds 1.5 dm in width except in some individuals perhaps referable to var. *robustum*; in addition, the terminal raceme is always present and may comprise up to 20–70% of the total inflorescence length (Fig. 3). Furthermore, in *S. gramineum*, secondary branches are infrequent and generally less than 2 cm long.



FIG. 2. *Stenanthium diffusum* habit at anthesis. Image taken at type locality, Ladder Trail, Pickett State Park, Pickett County, Tennessee.

TABLE 1. Morphological and other comparisons of *Stenanthium diffusum* and *S. gramineum*. Quantitative values are based on measurements from specimens deposited in the University of Tennessee Herbarium (TENN).

	S. diffusum	**S. gramineum**
Pedicel length at mid-portion of lateral inflorescence branches (mm)	(1–)1.6–4(–5)	(0–)0.3–1.1(–1.7)
Distance between pedicels at mid-portion of lateral inflorescence branches (mm)	(5–)8–15(–18)	(1–)3–7(–8.5)
Distance from ground to uppermost cauline leaf (cm)	(3–)4–14(–15)	(15–)22–66(–76)
Distribution	northern Cumberland Plateau of TN	FL to TX, n to IN and PA
Flowering period (at ca. same latitude)	mid-Sep to mid-Oct	May to late Aug
Habitat	moist, shady, sandstone rockhouses	dry to mesic woodlands and open areas

Stenanthium diffusum and *S. gramineum* also may be separated by quantitative morphology, phenology, distribution, and habitat (Table 1). The flowers of the mid-portion of the lateral inflorescence branches of *S. diffusum* are separated from each other by ≥8 mm and are borne on distinct pedicels (≥1.6 mm long) that often equal or exceed the subtending bracts. In comparison, the flowers of the lateral inflorescence branches of *S. gramineum* are sessile or subsessile on pedicels (≤1.1 mm long) that are equal to or shorter than the subtending bracts and are separated from each other by ≤7 mm, giving the inflorescence a less diffuse appearance. Interestingly, although the pedicels on the lateral branches are sessile or subsessile, those of the terminal wand-like raceme are distinctly pedicellate and may be up to 5 mm long. Another reliable characteristic that readily separates *S. diffusum* and *S. gramineum* is the distance from the ground to the node of the uppermost cauline leaf (not bracteal inflorescence leaf). The distal-most cauline leaf of *S. diffusum* is ≤14 cm above ground level whereas the distal-most cauline leaf of *S. gramineum* is ≥22 cm above ground level. Although somewhat difficult to quantify from herbarium material, there also appears to be a difference in leaf length/width ratio between these taxa, with the tendency toward a lower leaf length/width ratio in *S. diffusum*.

Other non-morphological differences include: (1) phenological differences, i.e., *S. diffusum* flowers from mid-September to mid-October and *S. gramineum*, at this approximate latitude, flowers from May to late August, (2) *S. diffusum* is a narrow endemic to the northern Cumberland Plateau of Tennessee in sandstone rockhouse habitats characterized by siliceous soils, low light intensity, high relative humidity, lower evaporation rates, and lower summer and higher winter temperatures than the surrounding forests. The more widespread *S.*

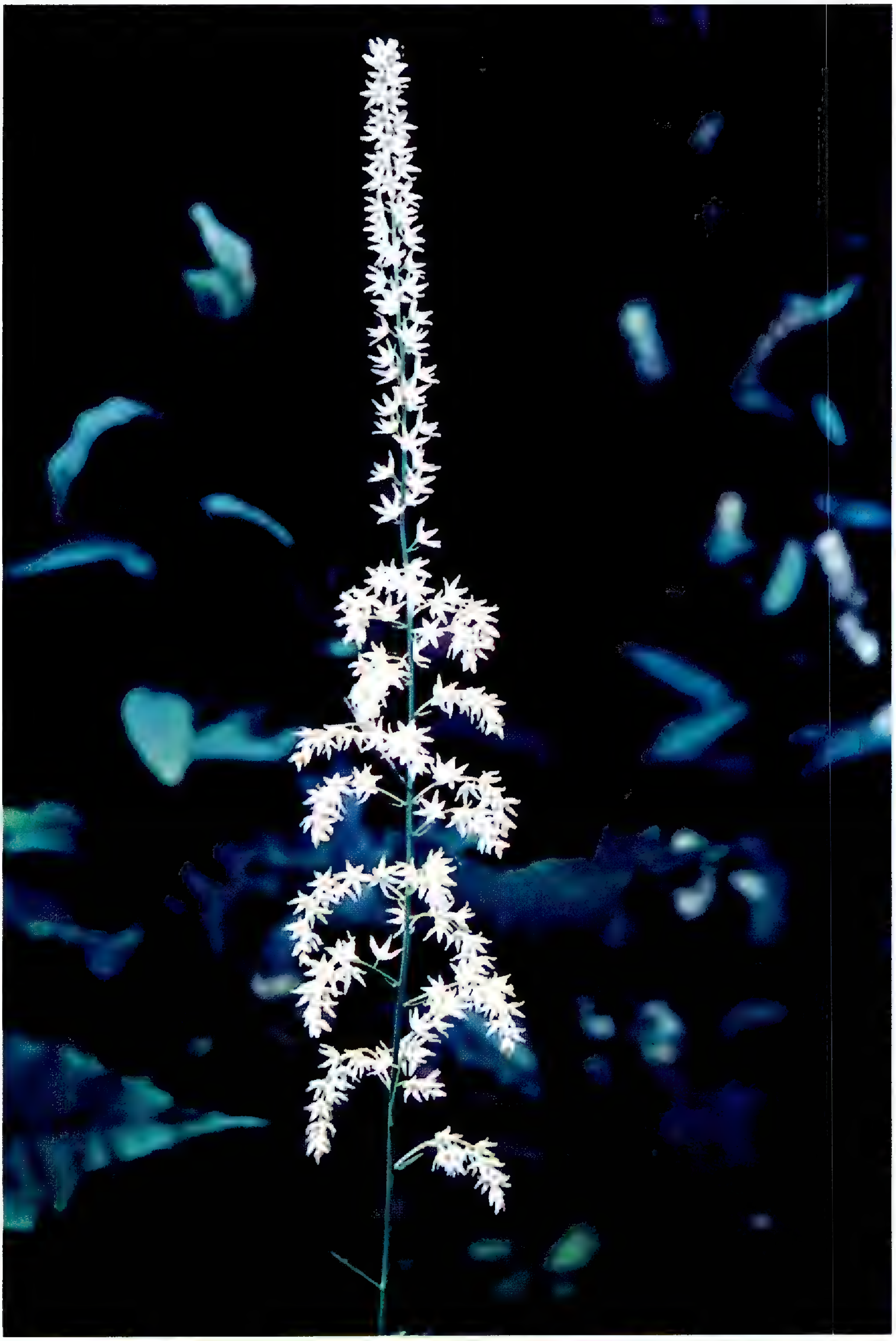


FIG. 3. *Stenanthium gramineum* habit at anthesis.



FIG. 4. *Stenanthium diffusum*, image of flowers at mid-portion of lateral inflorescence branch, from holotype.



FIG. 5. Habitat of *Stenanthium diffusum*. Sandstone rockhouse formations at type locality, Ladder Trail, Pickett State Park, Pickett County, Tennessee.

gramineum occurs in a much broader range of ecological conditions in numerous habitats including rich woods, moist to dry woods, meadows, flood plains, prairies, and grassy balds. The following key is provided for ease of identification:

1. Inflorescence a diffuse panicle up to 3 dm wide, the terminal racemose portion reduced or absent; flowers on mid-portion of lateral branches with distinct pedicels 1.6–4 mm long and 8–15 mm apart; uppermost non-bracteal stem leaf 4–14 cm above ground level _____ **S. diffusum**

1. Inflorescence not diffuse, typically up to 1.5 dm wide, the terminal racemose portion present and up to 3 dm long; flowers on mid-portion of lateral branches with pedicels 0.3–1.1 mm long and averaging 3–7 mm apart; uppermost non-bracteal stem leaf 22–66 cm above ground level _____ **S. gramineum** (including var. *micranthum* and var. *robustum*)

CONSERVATION CONCERNS

The northern Cumberland Plateau of Tennessee and adjacent Kentucky harbors a suite of species commonly referred to as rockhouse plants. This unique flora is restricted to sandstone floors, ledges, and overhangs. There are several

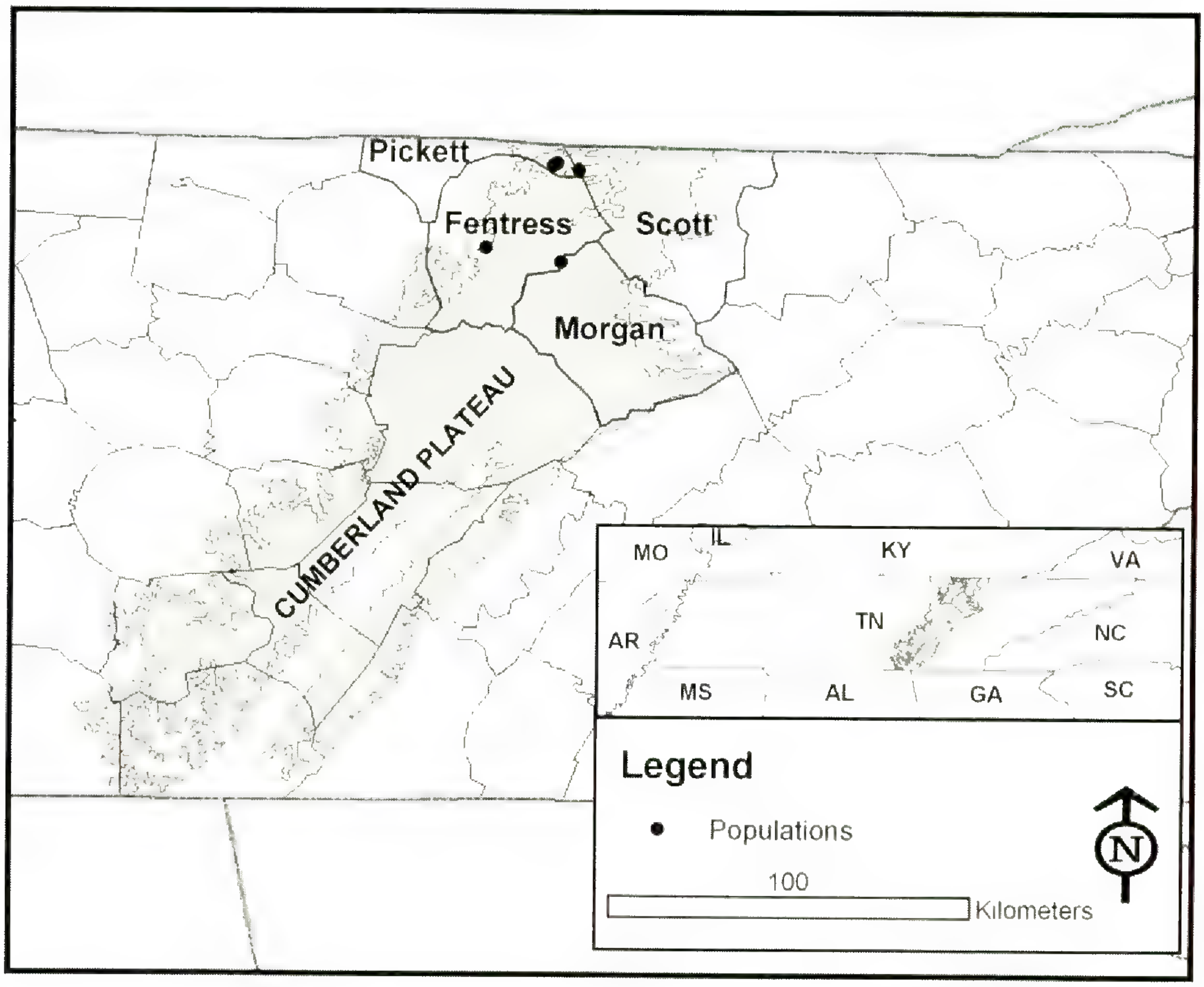


FIG. 6. County and within county distribution of *Stenanthium diffusum*.

critical factors required, in concert, to maintain these unique habitats: moist sandy soil, low light intensity, high relative humidity, low evaporation rate, and lower summer and higher winter temperatures than adjacent forests (Wofford & Smith 1980).

The environmental factor most likely to have an immediate and negative impact would be removal or severe thinning of adjacent woodlands. This would increase light intensity and temperature while reducing relative humidity and moisture. An aggressive management plan should be placed into motion on public lands (especially at Pickett State Park and Forest and the Big South Fork National River and Recreation Area) aimed at protecting a part of this critical habitat and its associated flora. In addition to protecting a unique part of Tennessee's natural heritage, protection would provide opportunity for study of biological/evolutionary problems yet to be resolved, i. e., speciation and sister pair relationships, micro and macroclimates, endemism, rarity, etc. Therefore, it is highly recommended that the Tennessee Department of Environment and Conservation and the U. S. Fish and Wildlife Service, in coordination with public land managers, conservation groups, and interested individuals, propose

both state and federal endangered status for *Stenanthium diffusum*. Hopefully, these efforts can, in concert, accomplish the necessary management and mission plans to preserve this unique habitat and flora.

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I thank the directors/curators of MO and BRIT/VDB for providing images of specimens. Special thanks goes to the faculty and graduate students at the University of Tennessee for their companionship on numerous field trips; to Dwayne Estes who carefully reviewed early drafts of the manuscript; to Guy Nesom who provided the Latin diagnosis; to Chris Fleming for constructing the distribution map; to anonymous reviewers for their helpful comments, to Jerry Drown for providing the image of *Stenanthium gramineum*, and to the Hesler Fund, University of Tennessee, for funding field trips.

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Book Review

Ria Loohuizen. 2005. **The Elder in History, Myth and Cookery.** (ISBN 1-903018-31-5, pbk.). Prospect Books, Allaleigh House, Blackawton, Totnes, Devon TQ9 7DL, United Kingdom. (**Orders:** The David Brown Book Co., P.O. Box 511, 28 Main St., Oakville, CT 06779, U.S.A., 860-945-9329, 860-945-9468 fax, Email: david.brown.bk.co.snet.net). $17.95, 140 pp., 5 1/2" × 7 1/4".

This petite book is an affectionate ode to the European elder (*Sambucus nigra*). It includes chapters on elder botany, mythology, and cuisine, as well as medicinal and other uses for the plant. In a chapter titled "The Healing Elder," the author reviews traditional medicinal uses of the elder. The proper harvest and drying of elderflowers, elderberries, and leaves is covered. Directions for making ointments, syrups, poultices, hair conditioners, and teas are described in detail. Recent studies have shown that the European elder has antiviral and adaptogenic effects, supporting its traditional use as a treatment for colds A chapter named "The Culinary Elder" describes elder recipes, which include such delicacies as elderflower fritters, elderflower wine, elderberry jelly, hot and sour soup, and recipes for the Jew's Ear mushroom (*Auricularia ariculae-judae*), which grows on dead elder wood. These recipes can be prepared using the American elder (*Sambucus canadensis*). However, caution should be used because large amounts of elderberries and bark can have an emetic effect. Peppered throughout the book are illustrations, photographs, and quotes related to the elder. The author finishes with a quote by the poet Seamus Heany: "I love its blooms like saucers brimmed with meal, its berries a caviar of shot, a buoyant spawn, a light bruised out of purple. Elderberry? It is shires dreaming wine."—*Marissa N. Oppel, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, Texas 76102-4060, U.S.A.*

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A NEW SPECIES OF *DODECATHEON* (PRIMULACEAE) FROM THE NORTHERN COAST RANGE OF OREGON AND WASHINGTON

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ABSTRACT

Dodecatheon austrofrigidum is described as a species occupying scattered sites in the Coast Ranges of northwestern Oregon and adjacent Washington, U.S.A. It is similar in floral morphology to, but widely disjunct from, *D. frigidum*, a species of the interior mountains and arctic tundra of Alaska and northern British Columbia. It also is ecologically distinct, being associated with streams, waterfalls, cliffs, rocky river banks, and high elevation moist grassland and basalt talus slopes in a maritime climatic zone. Its relationships are with members of Sect. Dodecatheon, but its seedling morphology is different from any described thus far in the genus. Morphology of the seed testa is illustrated by scanning electron microscopy.

RESUMEN

Dodecatheon austrofrigidum se describe como una especie que ocupa lugares espaciados de la Cordillera Costera del Noroeste de Oregon y de Washington, U.S.A. Es similar en la morfología floral, pero muy disyunta de, *D. frigidum*, una especie de las montañas interiores y la tundra ártica de Alaska y norte de British Columbia. También es ecológicamente diferente, estando asociada a arroyos, cascadas, acantilados, lechos rocosos de ríos, y praderas húmedas a gran altitud y laderas basálticas en una zona climática marina. Está relacionada con los miembros de la Sect. Dodecatheon, pero la morfología de sus plántulas es diferente de cualquiera de las hasta ahora descritas en el género. Se ilustra la morfología de testa seminal al microscopio electrónico de barrido.

INTRODUCTION

The northern Coast Ranges of Oregon and immediately adjacent Washington, especially on the higher peaks, are known to harbor a small suite of endemic plant species. Prominent in this list are *Cardamine pattersonii* L.F. Hend., *Castilleja chambersii* M. Eggers & R. Meinke, *Erythronium elegans* P. Hammond & K.L. Chambers, *Filipendula occidentalis* (Wats.) Howell, and *Saxifraga hitchcockiana* Elvander. A floristic affinity to the Olympic Mountains and coastal Alaska is suggested by more northern taxa whose ranges extend south to this region. These include *Carex macrochaeta* C.A. Mey., *Cladothamnus pyroliflorus* Bong., *Erigeron peregrinus* (Pursh) Greene var. *peregrinus*, *Lewisia columbiana* var. *rupicola* (English) C.L. Hitchc., *Prenanthes alata* (Hook.) Dietr., *Saxifraga caespitosa* var. *emarginata* (Small) Rosend., *Senecio flettii* Wieg.. and

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Synthyris schizantha Piper (Chambers 1973, 1974). Saddle Mountain, Clatsop County, Oregon, is a well known botanical site where many of these species have been found (Detling 1954).

Also known from Saddle Mountain, near the 1000m summit, is a dwarfed form of *Dodecatheon*, which the monographer, H.J. Thompson (1953, p. 118) referred, with some hesitation, to *D. pulchellum* (Raf.) Merrill (his *D. radicatum* Greene). A number of years ago I was directed to populations of vigorously growing examples of this plant along the Trask River, Tillamook County, Oregon, which I brought into cultivation. This tentative new species was then made known to interested botanists under the name *Dodecatheon austrofrigidum*, which has now come into general use for the plant. I here provide a description and further documentation of this species.

Dodecatheon austrofrigidum K.L. Chambers, sp. nov. (**Figs. 1, 2**) TYPE: U.S.A. OREGON. Tillamook Co.: Trask River Rd., 6.1 mi E of junction with Long Prairie Rd., T1S, R8W, S28, elev. ca. 200 ft, in patches of moss on bare, sloping rocky bank of the Trask River, between low and high water marks, with *Saxifraga nuttallii*, *S. mertensiana*, *Mimulus guttatus*, 13 May 1989, *K.L Chambers 5436* (HOLOTYPE: OSC; ISOTYPES: FSU, G, MARY, MO, NY, OSC, UC, US, WS, WTU).

Planta ad *Dodecatheon frigidum* et *D. dentatum* similis foliis variis glabris calyce glabro dentibus triangularibus acutis lobis corollae lavandulis tubo corollae albo filamentis fere liberis connectivis antherarum purpureis laevibus stigmate non capitato ab *D. frigido* radicibus numerosis fibrosis validis caudice plerumque per annos paucos persistenti differt, ab *D. dentato* corolla lavandula non alba differt; chromosomatum numerus $2n = 88$.

Perennial herb; **roots** numerous, stout, fibrous, often producing adventitious buds; **caudex** usually short-lived, with subsequent years' vegetative growth arising from a terminal bud or from small buds on the roots; **leaves** in a basal rosette, glabrous, variable, 2.5–30 cm long, 0.7–7 cm wide, ovate to broadly or narrowly elliptic, gradually or abruptly tapering to the petiole, margins entire to irregularly sinuate-dentate or denticulate; flowering **stems** scapose, 5.5–45 cm high; **inflorescence** a bracteate umbel of 1–7 pedicelled flowers, bracts 2.5–10 mm long, pedicels 4–55 mm long, glabrous to glandular-puberulent, especially distally; **calyx** 5–11 mm, tube 1–2.5 mm, lobes 3–9 mm, triangular, acute; **corolla** lobes 9–23 mm long, 2–6 mm wide, lavender, tube 1–2 mm long, white with a sinuous purple line where reflexed; **anthers** purple, 4.5–8 mm long, filaments 0.5–1 mm, free or slightly united, purple, connective smooth, purple; **style** exserted, stigma not capitate; **capsule** 6–16 mm long, 3.5–5.5(–7) mm wide, teeth ca. 1/5 of total length, dehiscence operculate or valvate; **seeds** 1–2 mm, irregularly rounded or prismatic, foveolate (Fig. 2); **seedlings** with petiolate cotyledons, the first principal adult root produced adventitiously from the apex of the hypocotyl, the first true leaf petiolate, arising between the cotyledons (Fig. 3). The chromosome number is tetraploid on the base of $x = 22$ characteristic of the genus.



FIG. 1. *Dodecatheon austrofrigidum* K.L. Chambers. **A.** Habit. Scale=2 cm. **B.** Flower. Scale=7 mm. **C.** Capsule with operculum. Scale=7 mm.

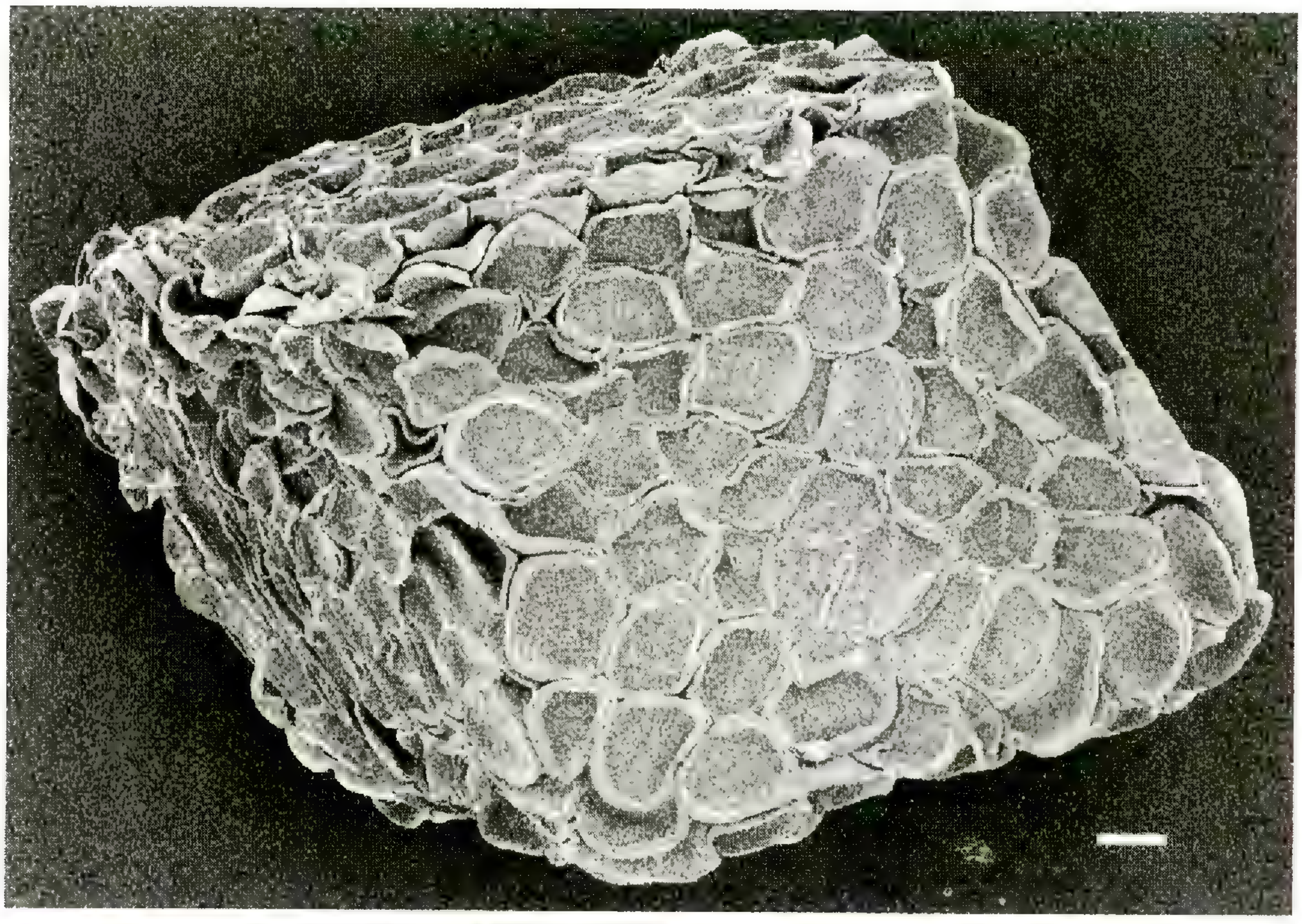


FIG. 2. Seed. Scale=0.1 mm.

Distribution.–Ranging from 30–1200 m, at scattered sites from the southern Olympic Mountains, WA (Mt. Colonel Bob) to Tillamook County, OR, both at high elevations in moist, grassy turf (Saddle Mountain and Onion Peak, Clatsop Co., OR) and in forested regions, where the habitats include moist basaltic slopes, talus, and cliff-faces, especially near waterfalls and streamlets. Further populations occur at low elevations in Tillamook Co., on bare or mossy basalt rock banks of rivers, between the low- and high-water marks, in the winter flood-scour zone (Raven 1995, 1996). Plants in this peculiar habitat probably become established by seeds washed down from the mountain populations, and their tenacious mass of strong roots, penetrating crevices in the rock, anchors them from being washed away during the period of winter flooding. The species is allopatric in range to all other members of the genus.

Flowering.—April–July, depending on habitat and elevation. Flowers are self-fertile and capable of self-pollination in cultivation.

Relationship.—Thompson (1953) recognized three sections within the genus, differentiated by characteristics of the stigmas, capsules, seeds, and seedlings. The new species is best assigned to Sect. Dodecatheon, with the proviso that *D. frigidum* Cham. & Schltdl. should also be placed in this section, rather than Sect. Purpureo-tubulosa of Thompson. The corrected placement is strongly supported by molecular evidence provided by Mast et al. (2004) and by the

marked floral similarity between *D. frigidum* and *D. austrofrigidum*. Mast et al. (2004) show a strict consensus tree based on seven cpDNA regions, in which *D. frigidum* is sister to the group of other taxa in Sect. Dodecatheon, rather than forming a clade with *D. conjugens* Greene in Sect. Purpureo-tubulosa, as proposed by Thompson. In this DNA-based phylogeny, *D. austrofrigidum* is paired in Sect. Dodecatheon with *D. dentatum* Hook. ssp. *utahense* (N. Holmgren) Kartesz (perhaps itself a distinct species).

Dodecatheon austrofrigidum differs in two significant features from the morphological characterization of Sect. Dodecatheon given by Thompson (1953). These, and an improved knowledge of the seed testa based on SEM studies (Fig. 2), will be discussed in turn. Most important, I believe, is that seedling morphology and development are distinctly different than had been described for this section. In *D. austrofrigidum*, the seed begins with two petiolate cotyledons (as Thompson, 1953, Fig. 1g, illustrates for *D. pulchellum*). The first true leaf, itself petiolate, next arises from between these cotyledons. Finally, a strong, major adult root forms adventitiously at the base of this first true leaf, between the cotyledons, replacing the seedling's initial but ephemeral root system (Fig. 3). In the seedling of *D. pulchellum* (*D. radicatum*) illustrated by Thompson (loc. cit.), the first true leaf is linear-spatulate, not petiolate, and arises adventitiously from the hypocotyl well below the cotyledons; the new adventitious major root grows downward from that same point on the hypocotyl. Neither of the other two seedling types illustrated by Thompson (loc. cit.) resembles that of *D. austrofrigidum*.

The mature capsules of *D. austrofrigidum* differ in their dehiscence mode from that described for Sect. Dodecatheon (Thompson, op. cit., p. 79). The section is characterized as having valvate capsules, but in *D. austrofrigidum*, they are most often operculate instead. Capsules are thin-walled below and have an indurate apex where the cells are thick-walled and isodiametric. As these cells dry at maturity and shrink, tensions develop that rupture the tissue and open the capsule for seed dispersal (Fig. 1C). A transverse rupture through the tip region causes an operculum to free itself, carrying with it the dried style. Usually five lengthwise splits also occur at the same time, but some of the five teeth thus formed may in turn split in half, so that dehisced capsules may be found with up to ten teeth. In a sample of 181 capsules, the average number of teeth was 6.28, the numbers of capsules with 5, 6, and 7 teeth being approximately equal. The initial five splits can often be observed in the operculum (Fig. 1C). Valvate dehiscence, where the lengthwise splits reach the apex, is usually noted in smaller, less robust capsules.

Seeds of *D. austrofrigidum* (Fig. 2) conform to the description of Sect. Dodecatheon (Thompson op. cit., p.75–76). They are irregular in shape but often flattened on two or more sides, becoming even more prismatic than in Thompson's drawing (op. cit., Fig. 1f). They do not resemble the membranous-

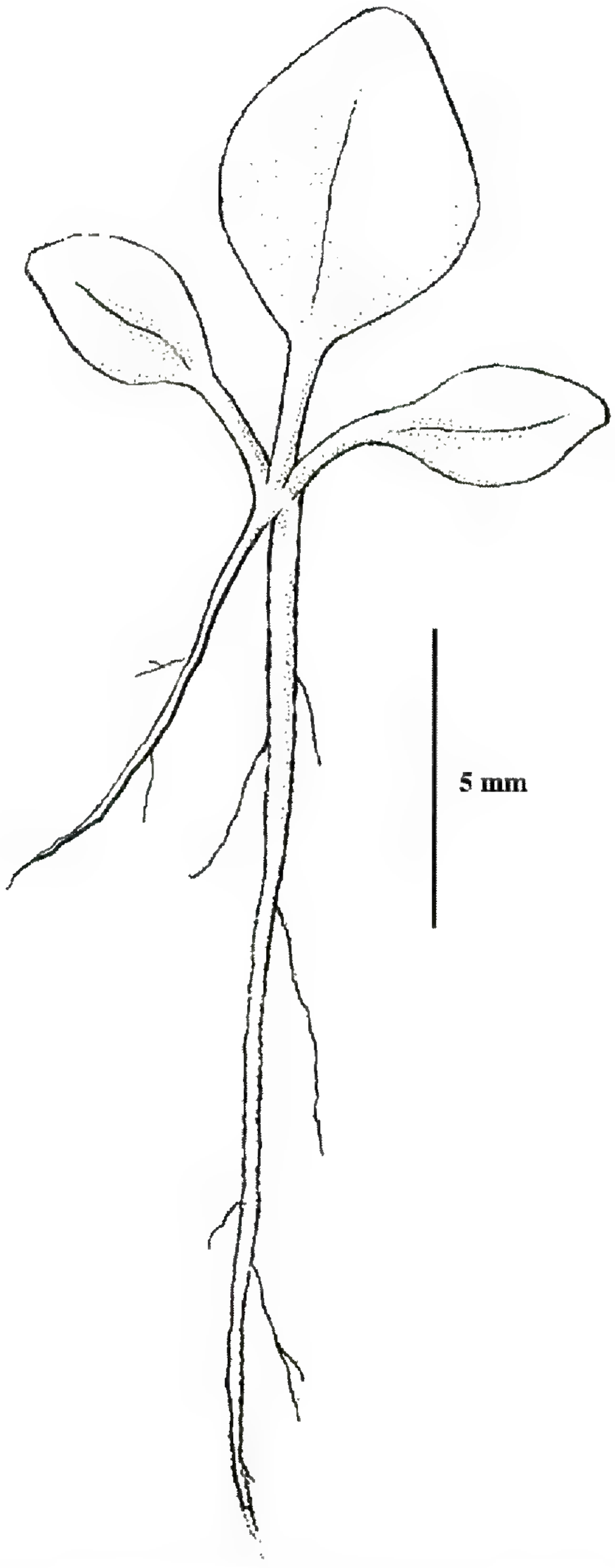


FIG. 3. Seedling, showing petiolate cotyledons and first leaf. A major adventitious root, right, replaces the initial, short-lived seedling hypocotyl and root at the left. Scale=5 mm.

margined seeds of Sect. Capitulum (Thompson loc. cit.). The testa is formed initially of tightly packed bulbous cells, which at maturity deflate into irregular, rimmed, dish-shaped foveae (Fig. 2), best visualized by SEM. In view of these newly published observations on *D. austrofrigidum*, it is likely that a survey of

seed, seedling, and capsular morphology in all the species will contribute to an improved understanding of intrageneric relationships.

Cited collections: **U.S.A. OREGON. Clatsop Co.:** Onion Peak, elev. 3064 ft, T4N, R10W, S22, 29 Jun 1971, *Chambers 3169* (CAS, OSC); same, 21 Jul 1971, *Chambers 3258* (OSC); Saddle Mtn, T6N, R8W, S33, 29 May 1972, *D. Jaques 973* (OSC); same, elev. 2600 ft, T6N, R8W, S19, 24 May 1950, *Detling 6550* (CAS, ORE, UC); Saddle Mtn, elev. 3200 ft, 10 Jun 1928, *G. R. Patterson s.n.* (ORE). **Tillamook Co.:** Trask River Rd. at 9.5 mile marker, on basalt bank of Trask R., 29 Jun 1980, *Chambers 4694* (OSC); same, 10 Jun 1979, *G. Lewis s.n.* (OSC); Standard Grade Rd. above Elk Ck., elev. ca. 3200 ft, T2N, R7W, S13, photo, Jun 1981, *G. Lewis s.n.* (OSC); near Diamond Falls, Tillamook State Forest, elev. 1480 ft, T2N, R9W, S32, 13 Jun 2001, *Chambers 6300* (OSC); Kilchis Falls, Tillamook State Forest, elev. 1540 ft, T1N, R8W, S3, 13 Jun 2001, *Chambers 6299* (OSC). **WASHINGTON. Grays Harbor Co.:** Mt Colonel Bob, above Moonshine Flats, elev. 3800 ft, T23N, R8W, S18, 20 Jul 1983, *E. Alverson 590* (OSC); same, 6 Jul 1994, *D. Davis s.n.* (OSC). **Pacific Co.:** Willapa Hills, headwaters of West Fork of Grays R., elev. 1500 ft, T11N, R7W, S10, 12 Apr 1994, *J. Powell 1324* (OSC); same, elev. 1800 ft, 23 Apr 1995, *J. Powell 1410* (OSC).

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Book Review

William C. Burger. 2006. **Flowers: How they Changed the World.** (ISBN 1-59102-407-2, hbk.). Prometheus Books, 59 John Glenn Drive, Amherst, NY 14228-2197, U.S.A. (**Orders:** 716-691-0133, 716-691-0137 fax, http://www.prometheusbooks.com/). $23.00, 337 pp., b&w figures, color photographs, glossary, and notes, 5" × 7".

William Burger has written a book that is hard to put down. *Flowers: How they Changed the World* is a fantastic introduction to the angiosperms, their evolutionary advances, and the roles plants play in the evolutionary history of man. This book is written in such a way that it will appeal to those readers looking for an introduction to flowering plants. However, it also provides the seasoned readers much food for thought. The writing style is very casual and conversational with a good deal of wit, yet includes an abundance of information. The book covers many topics including: what is a flower, the purpose of flowers, flower friends, flower enemies, how to distinguish flowering plants, what makes flowering plants special. It also discusses how primates, people and flowering plants relate to each other and in the end how flowers changed the world. Topics flow well into each other, which greatly adds to the readability of the text.

The author is clever about introducing new subjects and making these topics non-threatening. For example, the book starts with introductions to four plants, a geranium, rose and two lilies. The author hints at the importance of distinguishing traits between monocotyledons and dicotyledons, but doesn't delve into more detail until later chapters; smartly building on these unassuming introductions made in the first chapter. This book contains well-written discussions and a wonderful introduction to major evolutionary advances in plant reproductive biology. Among these are how pollen helped flowering plants do well on land, the value of deciduous leaves, the biology related to losing leaves from a plant, and the evolutionary advances in plant defenses of chemicals that help prevent herbivory and disease. The author includes many other interesting discussions on subjects such as the importance of out-breeding in plants and how plants have adapted ways to promote out-breeding, as well as the diversity in form and structure of flowering plants. The books final chapters cover information on how plants have been important to people, focusing on mankind's development of agriculture and the importance of biodiversity to our lives and the Earth. There is also a section that summarizes the important role plants have played in creating our world and the modern lives of man in ten major stages.

Flowers: How they Changed the World by William Burger is an extraordinary and interesting book to read; full of engaging information for readers of all ages, educational backgrounds and interests. The text is written in an easygoing style and covers a wide range of topics related to the evolution and biology of flowering plants. The author has also gone above and beyond typical notes for the reader; he provides both information and references for each chapter topic accented by his own educated valuable comments.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

THE LECTOTYPIFICATION AND 19TH CENTURY HISTORY OF *CROTON ALABAMENSIS* (EUPHORBIACEAE S.S.)

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ABSTRACT

A detailed account is presented of the historical events relating to the discovery of *Croton alabamensis* var. *alabamensis* (Euphorbiaceae s.s.) by E.A. Smith in 1877 and its subsequent study by 19th century American botanists. A lectotype is designated and its provenance discussed.

RESUMEN

Este artículo presenta una descripción detallada de los eventos relacionados con el descubrimiento de *Croton alabamensis* var. *alabamensis* (Euphorbiaceae s.s.) por E.A. Smith en 1877 y su estudio subsiguiente por botánicos en el siglo XIX. Además, se designa un lectotipo para esta especie y se discute su origen.

INTRODUCTION

The progress of botany in the southern United States during the latter half of the 19th century has generally not been critically studied. Most of the major figures have yet to be treated by more than brief biographical sketches. Historical narrative is usually traced from the perspective of a particular person or institution, but a few rare southern plants (e.g., *Croton alabamensis* E.A. Sm. ex Chapm., *Dionaea muscipula* Ellis, *Elliottia racemosa* Muhl. ex Ell., *Franklinia alatamaha* Bartr. ex Marsh., *Shortia galacifolia* Torr. & A. Gray, and *Torreya taxifolia* Arn.) have attracted sustained botanical interest from discovery to the present day and are therefore of noteworthy historical interest. *Croton alabamensis* contains an especially rich and complete historical record that is chronicled here to recover lost details about the type collection and reveal extensive and collegial interactions among the network of botanists of the day.

Croton alabamensis is, in habit, the largest native United States representative of the tropical-centered family Euphorbiaceae s.s. The species has a disjunct distribution between Alabama and Texas and contains two morphologically well-differentiated, geographically-named varieties (vars. *alabamensis* and *texensis* Ginzbarg, respectively). *Croton alabamensis* is readily distinguished from other North American species of *Croton* L. by its shrubby habit, petaliferous female flowers, and covering of lepidote scales that give the abaxial leaf sur-

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faces a silvery appearance. Webster initially suggested its affinities were with section *Andrichnia* Baill., but later referred it to section *Lamprocroton* Müll. Arg. and then section *Argyrocroton* (Müll. Arg.) G.L. Webster (Webster 1967, 1996; Webster et al. 1996). Recent molecular phylogenetic studies have affirmed a sister relationship between the two varieties and suggested new affinities with a small "basal" *Croton* group (*Moacroton* clade) containing Cuban endemics *Moacroton* Croizat and *Cubacroton* Alain and other *Croton* species (mostly section *Corylocroton* G. L. Webster) ranging from the Caribbean to Central and South America (Berry et al. 2005; van Ee & Berry 2005; Wurdack et al. 2005; van Ee et al. in press).

Croton alabamensis var. *alabamensis* is known from central Alabama and a single probably erroneous report from central Tennessee (see below; Farmer & Thomas 1969; Wofford & Chester 2002). In Alabama the typical variety occurs in Tuscaloosa County along the Black Warrior River and in adjacent Bibb County from the Cahaba River drainage. It was first discovered in Bibb County by Eugene A. Smith in 1877. Ironically, Smith was apparently unaware of the populations along the Warrior River in his home county, Tuscaloosa, which were found by Roland M. Harper in 1905 (Harper 1906b). *Croton alabamensis* var. *texenesis* was an unexpected discovery in 1989 from Texas, 1000 km away from the typical variety (Ginzbarg 1991, 1992; Aplet et al. 1994).

The Alabama plants from the Black Warrior and Cahaba river systems are separated by ca. 40 air km but show morphological, cytological, genetic, and ecological differences (Farmer 1962; Farmer & Thomas 1969; van Ee et al., in press). The plants are semi-evergreen and undergo meiosis and bloom in early spring (February and March) from overwintering flower buds formed the prior season. In Bibb County the *Croton* forms dense understory thickets from 1–2.5 m tall at 76–91 m of elevation in thin soils over limestone or dolomite above waterways within an 8 km radius of Pratt's Ferry, an area roughly bounded by Schultz Creek on the west and Six Mile Creek to the east. The Cahaba River and its nearby tributaries cut steeply through the bedrock to form numerous dry rocky bluffs on which the *Croton* is especially abundant.

Pratt's Ferry has been reported to be the type locality of *Croton alabamensis* var. *alabamensis* and, as one of the most easily accessible localities for the plant, has been the source of numerous recollections. Pratt's Ferry was a public ferry crossing of the Cahaba River just south of the community of River Bend and was probably named (although the Pratt family had many members in the area) for Mary Pratt (1800–1882), who ran the ferry from 1854 through at least the Civil War (Ellison 1984). Pratt's Ferry and aptly named River Bend are at a large bend in the river where a ferry crossing could be established with relative ease. An iron bridge was built at the crossing in 1902 (Harper 1906a; the old roadbed is evident on the south side of the river and an iron pylon for this bridge remains on the north shore, pers. obs.) that was superseded by the present bridge

crossing of County Road 26 just downstream from (west of) the original bridge. The exact nature of the ferry landings has been obscured. However, based on topography (i.e., limitations imposed by adjacent bluffs), the ferry route appears to have diagonally spanned the river with the northern landing upstream and the southern landing downstream of the current bridge. In the vicinity of Pratt's Ferry, the *Croton* presently occurs on the north side of the river in a small population immediately west of the current bridge and on the south side as a more or less continuous band east of the bridge for at least 1.6 km (pers. obs.).

Despite a sustained interest in *Croton alabamensis* since its discovery in 1877 and concomitant visits to Bibb County by many botanists, the flora in the area has only recently been documented and found to be rich in endemic and disjunct taxa (Allison & Stevens 2001). Most of the endemics occur on ecologically sensitive patchy glades (Ketona Glades) developed over Ketona Dolomite. Populations of the *Croton* in the Cahaba River drainage are often found around, but not restricted to, the fringes of the Ketona Glades (pers. obs.). Despite occasional logging activities, the region appears relatively unspoiled, remote, and undeveloped today and similar to a vintage 19th century riverbank photograph (Davenport 1988:40). A very different picture emerges when looking at the historical record of regional industrialization. Taken in that light, Charles Mohr's dire prediction over 100 years ago that the survival of the *Croton* in its native habitat "will in all probability be of short duration" may not have been unfounded (Mohr 1889). The limited distribution of both *Croton* varieties, as well as the Ketona Glade flora, has caused conservation concerns. Some habitat in Bibb County has been recently preserved (i.e., The Nature Conservancy's Bibb County Glades Preserve).

Discovery of *Croton alabamensis*

Eugene Allen Smith (1841–1927), professor of geology and mineralogy at the University of Alabama, was appointed State Geologist in 1873 of the newly re-established Alabama Geological and Agricultural Survey. He began surveying the geology of the state during summer expeditions in a custom-built field wagon (modeled after a horse-drawn ambulance and preserved at the University of Alabama) in a manner documented in photographs (see Wolfe 1983:99) and in his copious geological field notes (Smith 1870–1889). Although the original field notebooks were lost, transcriptions made during a 1930's Depression-era public works project (probably WPA or preceding agencies) remain and allow a detailed picture of Smith's field activities to be reconstructed here. His recurring interest in Bibb County was economically oriented toward an investigation of coal and iron deposits that had originally made the region a leader in antebellum iron production (Ellison 1984). In the mid-19th century the Bibb County countryside was dotted with ironworks, mill dams, stone quarries, mines for ore (limonite) and coal, and associated communities. Today few traces

remain of this industrialization and the environmental degradation it caused is scarcely evident. Once thriving industrial communities are now extinct (i.e., Tionis) or severely depopulated (i.e., River Bend and Six Mile).

Smith first explored Bibb County in 1873 and in more detail in 1875. On August 17, 1875 he collected ore samples and explored associated Brighthope ironworks or "bloomery" (originally called Little Cahaba Furnace and in operation by 1850; Ellison 1984), the first blast furnace in the county and about 140 m above a wooden dam (Browne's Dam) on the Little Cahaba River that provided its power. The seats for the dam timbers appear today as a series of steps cut into a riverbank rock outcrop at the Bibb County Glades Preserve near Bulldog Bend (pers. observ; Ellison 1993:51). The apparent present day natural state of this area, which contains some of the finest Ketona Glades, is remarkable considering the past destructive activities engendered by the adjacent ironworks, although it is also possible that disturbance supported or enlarged the glade community. The following day (i.e., August 18, 1875) Smith continued from the Sinks (sec. 26, T24N, R10E) on lower Six Mile Creek, where the creek flows underground except at flood stage, southwestward to Pratt's Ferry, where he noted fossiliferous "limestone" containing the gastropod *Maclurites magnus* LeSueur. It seems improbable that the *Croton* escaped visual detection, even if not considered noteworthy at the time.

The trip credited with the discovery of *Croton alabamensis* was from July 18 to August 4, 1877. On July 18, Smith left Tuscaloosa and on July 24 his geological party set up camp on the north side of the Cahaba River near Pratt's Ferry. On the way, Smith described an area near Schultz Creek "where the Coal Measures are cut off by a fault bringing up Knox Dolomite which in a series of glades or bare hills, with crumbling and much decomposed Dolomite stretches N.E. for a considerable distance" (entry for July 21; Smith 1870–1889). This is on the presently depauperate western end of the Ketona Glades zone and suggests that an extensive loss of glade habitat has since occurred. "Knox Dolomite" as used by Smith would have broadly included Ketona Dolomite which was named in 1910 (see Geological Survey of Alabama 1894).

The label with Smith's first collection of the *Croton* notes "Privet or Privy, Pratt's Ferry. 26. 7. 77" (see Fig. 1). I interpret the date notation as July 26, 1877. Privet is probably derived from the vernacular for *Eleagnus* spp., which *Croton alabamensis* vegetatively closely resemble. Smith rarely recorded botanical observations in his geological field notes, and July 26 is no exception. On that date, Smith spent the morning west of Pratt's Ferry on the north side of the river and then after lunch crossed over the river. On July 28, 1877, however, he makes a record of the *Croton* from a spot I estimate to be near the head of Little Schultz Creek, 3 km downstream from Pratt's Ferry. His field notes for that date read:



FIG. 1. *Croton alabamensis* var. *alabamensis*. Composite sheet including the first collection (branch in top center). Associated small label in bottom left (see enlarged inset at top) reads: "Type Spm.[Specimen]!" [hand of C. Mohr] "Privet or Privy. Pratts Ferry 26.7.77. belong[s] to Ala. Herb." [hand of E.A. Smith]. Geological Survey of Alabama label on bottom right reads: "On rich calcareous soil in copses [at] Pratts Ferry. Discovered by Dr. E.A. Smith. August 27th 1879. – forms dense thickets near the banks of the little Cahaba river. blooms in february. ripens fruit until May" [hand of C. Mohr].

"Went with Mr. Mat Wallace in his skiff from opposite the point of the mountain [eastern end of Big Mountain] down nearly opposite the ore bank. The limestone bluffs furnished exactly the proper ground for the greatest variety of ferns. Amongst those I had not seen before were *Ad*[*iantum*]. *capillus-veneris*, *Cheilanthes alabamensis* and one other which resembles it, but has lobed pinnules instead of entire ones. After climbing through an almost impenetrable thicket of what the natives call privet [*Croton alabamensis*] and another shrub now in flower [probably *Forestiera ligustrina* Poir] and extremely fragrant attracting thousands of bees we came to our ore bed" (Smith 1870–1889).

Smith later recalled "the [type] locality of *Croton alabamense*, is Pratts Ferry in Bibb County, on [the] Cahaba River and upon limestone. Date of discovery, August 1877" (Smith 1881d; confirmed in Smith 1907). Smith probably encountered the *Croton* at other times during this 1877 trip, and assuredly so (based on present distribution) on August 1 while on the Cahaba River bluffs, 0.4 km north of where Cottingham Creek joins the river, while examining where "Knox Dolomite" crosses. Smith appears not to have revisited the Pratt's Ferry area until August 1889, based on field note chronology and referring to his "observations of 12 years ago" (i.e., 1877). Mohr variously credits the discovery to 1874 (Mohr 1898, 1901), 1877 (Mohr 1889), or 1879 (Mohr 1887; see Mohr's label notation in Fig. 1). Smith (1881b) recalled, "I think I must be the discoverer as I know of no one else who has ever collected any of the material.... It makes almost inpenetrable "Privet Thickets" as they are called, and the peculiar aroma of the leaves as you feel your way through, is exceedingly characteristic. I have not seen the plant anywhere else, than along the banks of the Cahaba River where it grows upon limestone much like Cedar."

From press to print

In January 1878, Smith approached Charles Theodore Mohr (1824–1901) about preparing a mounted, organized herbarium for the Geological Survey from Smith's collections. Mohr's poor health and business obligations put the project on hold until May 1879, when he received the plants (Mohr 1879a). By July the *Croton* had come to Mohr's attention and he directed an inquiry to Smith:

"Amongst some other interesting plants collected at Pratts Ferry (v.i. *Forrestonia* [sic], *Forrestiera ligastrina* [sic] et al.) I find a shrub marked "Privet." Is it a truly indigenous plant or escaped from cultivation[?] It is very near *Eleagnus Canadensis* (the specimens being without flowers or fruit I cannot decide positively). It should be very strange indeed to find that Northern shrub at once coming up afar in Central Ala[bama]." (Mohr 1879b).

The specimen (Fig. 1) described by Mohr in this letter and annotated by him "Type Spm. [specimen]!" is apparently Smith's earliest collection previously noted; it is in young bud. Mohr later recalled, "I found first a sprigg [sic] of it amongst the plants of the Geol. Survey of Ala. collected by the Professor [Smith]; notwithstanding the poverty of the specimens bearing only a male spike with the flowers yet in the bud. I recognized as plant entirely new" (Mohr 1882a).

After examination of a single male flower, Mohr tentatively referred the *Croton* to section *Hendecandra* Eschw. and sent the specimens off to George

Engelmann (1809–1884) with a cover letter dated February 24, 1880, noting that "perhaps the plant is known to you from Texas or N. Mexico" (Mohr 1880b). Mohr wrote to Smith, "I was somewhat astonished to find the *Croton* (Privet) by Dr. Engelmann referred to *Cr. argyranthemum* [*Croton argyranthemus* Michx.], a straggly herb not infrequent in our dry pine barrens here... It will be necessary to secure large specimens with a portion of the lower stem to establish its character as a true shrub and in full bloom with male and female flowers, the plants appear to be dioecious" (Mohr 1880c). Little progress had been made by October 11, 1880, when Mohr reported to Smith, "the *Croton* continues to be [a] riddle to all who get hold of it" and lamented the lack of adequate fertile material. The lack of fertile material explains his belief that the plant was dioecious (it is actually moneocious, with typical bisexual *Croton* inflorescences), though by this time he had the remnants of female flowers (Mohr 1880d). Mohr recalled, "Some time later I was so fortunate to find a unripe capsule and a female flower, from which it was evident that it has its place amongst [sic] the section *Eleuteria*" (Mohr 1882a). There is no mention of the *Croton* in the Alabama floristic checklist Mohr and Smith published in 1880 (Mohr 1880a).

Mohr turned to Alvan Wentworth Chapman (1809–1899), who was then involved in the preparation of a second edition of his *Flora of the Southern United States* (i.e., Chapman 1883a). Mohr (1881a) wrote to Smith:

"I am glad to learn that you are on the lookout for the *Croton*. Can you not get a slip for me to plant in my garden? I have sent at his request all of the material I had received of yours (except that what I had sent before to Prof. Engelmann who certainly took a wrong view of it) to Dr. Chapman. He was anxious to describe the plant in the new edition of his Flora, he agreeing with me at first sight that [it] is new."

In the pursuit of more material, Chapman wrote directly to Smith, who replied April 8, 1881:

"The croton you mention is a shrub growing sometimes to the height of 8 to 10 feet. I have seen some trunks three inches in diameter. It makes an almost impenetrable thicket, and the aromatic odor from the bruised leaves is peculiar. I have a correspondent in the locality [probably Jacob S. Hansberger, see below] who has promised to get me specimens during each month of the year so that I may be able to get sufficient material for identification. Dr. Mohr has now all my material. When I get other specimens, I will remember to send you some" (Smith 1881a).

Chapman requested all the material Mohr had "on hand," and Mohr reported to Smith that the request had been honored including a specimen with "ripened fruit in perfect state" (possibly this collection is US-956957, see below) (Mohr 1881a, 1881b). In a letter dated July 10, Smith (1881b) reported that he was expecting new material in a "week or two," presumably from his "correspondent." He also approved Chapman's proposed name "*Croton alabamense*" (l.c.). On July 17, Smith was able to send Chapman "a small box containing specimens of *Croton alabamense*, in different stages of its growth." He continued, "From these, I hope you will be able to get all the information heretofore lacking. You might plant some of the seeds and perhaps raise it. I have several flourishing plants in

flower pots, which I have lately received from Pratt's Ferry" (Smith 1881c). These additional specimens proved sufficient for the complete description. The "18 inch seedlings" received from the "correspondent" in July 1881, Smith planted in his yard and they attained a height of "7 feet" by 1889 when Mohr reported on their development (Mohr 1889).

Chapman traveled north, meeting with Charles Mohr while passing though Washington (Mohr 1882b), and delivered the manuscript for his *Flora* to the printer in the last week of July 1882 (Chapman in Oakes 1932). Proof corrections continuing into the fall and the preface was dated December 26, 1882 (Chapman 1883a). Copies of the *Flora* were circulating by February 1883 (Chapman 1883b). The main body of the *Flora* was merely a corrected version of the first edition (Chapman 1860) and new taxa, including the *Croton*, were contained in an appended supplement. Chapman (l.c.) credited Smith as the authority for the species but added "ined.," an amendment finally removed in the entirely revised third addition of the *Flora* (Chapman 1897).

Mohr was preoccupied with work for Charles Sprague Sargent (1841–1927) on forest trees for the Tenth Census of the United States and could not visit Bibb County until November 1882 (vouchers at A, GH, MO and US variously give the date as November 11 or 12). Mohr located the *Croton* while collecting wood samples of *Quercus durandii* Buckley on his final trip for Sargent. Of the trip Mohr notes:

> "About the middle of last month I was over on the little Cahaba river near Tionus [sic]. I went by way of Montevallo; having to return the same day I made 32 miles on horseback, arriving at my quarters at Mr. Aldriches at 10 o'clock pm... At the time of my visit to the 'Privet' thickets near Tionus the plant was just putting forth the flower buds of the staminate spik[e]lets, which as Mr. Hansberger informs me open with the first warm days of early spring. Not a vestige of even a rudimentary pistillate flower could be found and the fruit of this season was entirely gone... Mr. Hansberger received me with the genuine warm hospitality of the southern gentlemen, he went with me through the woods and gave me all assistance in his power... I am bound to visit again this locality so rich on [sic] botanical treasures" (Mohr 1882c).

Tionis was a community located along lower Six Mile Creek (sec. 26, T24N, R10E; fide Smith 1870–1889) and readily evident on period maps (see online historical map archive at the University of Alabama, http://alabamamaps.ua.edu/index.html). A post office was established in 1870 and Jacob S. Hansberger (d. 1887) served as postmaster from 1874 until 1887 when it was discontinued prior to his death (Stewart 1983). Bibb County deed books show that he owned over 200 ha of land in the vicinity (accrued as many parcels over a period of years). Smith knew Hansberger from his Bibb County trips and they had explored Six Mile Creek together shortly after Smith first discovered the *Croton* (fide entry for August 1, 1877; Smith 1870–1889). It is probable that Smith instilled in Hansberger an interest in the *Croton* and that he served as Smith's "correspondent" and local expert. The exact locations of Tionis and Hansberger's house are presently uncertain and I have not been able to assess the patchy *Croton*

distribution in relation to them. Even today it is clear that *Croton* is readily available in the general area without having to travel all the way to Pratt's Ferry (ca. 6.4 km to the west).

In the fall of 1882 Frederick Hoffmann, editor of *Pharmaceutische Rundschau*, requested Mohr to submit an article on *Croton alabamensis* for that journal (Mohr 1882b). Mohr had noted that the *Croton* bark was of interest to "pharmacognosy" as a possible native substitute for cascarilla that came from the bark of the West Indian *Croton eluteria* (L.) Sw. Mohr decided to defer writing the article until he could obtain flowering material to clear up the "point of the sexual relation of their flowers" and have a photograph of the plant taken. In March 1883 Smith sent Asa Gray a print of the photograph (annotation on back of print says the photo was taken February 28, 1883; Smith 1883) and Mohr received a copy in May (Mohr 1883a). In June 1883, while collecting wood for the Louisville Cotton Exposition, Mohr returned to Pratt's Ferry, ostensibly for *Quercus durandii* wood, but also unsuccessfully for *Croton* seeds and flowering specimens. (Mohr 1883b).

Mohr's labors finally bore fruit. In a paper read in January 1884 before the Mississippi Valley Horticultural Society, he presented his views on the possible use of *Rhus cotinoides* (= *Cotinus obovatus* Raf.), *Neviusia alabamensis* A. Gray, and *Croton alabamensis* as horticultural subjects (Mohr 1884). The same three species were treated in an expanded form by Mohr for the January 1887 issue of *Pharmaceutische Rundschau* (Mohr 1887). An etching of a cultivated seedling was substituted for the originally intended photograph. Preparation for this article included the examination of additional blooming material that was collected by Smith in his garden and received by Mohr in April 1886 (Mohr 1886). This material probably included a collection in the Mohr Herbarium dated April 16, 1886 from "my yard (Tuscaloosa), transplanted from Pratt's Ferry" (*E.A. Smith s.n.*, UNA-00020895, annotated by Mohr "Type Spm."). In 1888, Mohr's preparation of an article for *Garden and Forest* brought renewed questions to Smith on the life history of the *Croton* and requests for specimens (Mohr 1888). Mohr hoped to have the article sent off to press by the end of August 1888 and it appeared in the December 11, 1889 issue of *Garden and Forest*. In March 1889 Smith sent seedlings of the *Croton* to Sargent and Mohr (Smith 1889).

Typification and historical collections

Chapman gave no collection data beyond "central Alabama" in his original description, therefore a lectotype is selected here:

Croton alabamensis E.A. Sm. ex Chapm., Flora of the Southern United States, ed. 2:648. 1883. LECTOTYPE: UNITED STATES. ALABAMA: *E.A. Smith s.n.* (US-935923, ex John Donnell Smith herbarium). Other original material: Alabama, 4 Apr 1881 (date given on supplemental tag attached to stem), *E.A. Smith s.n.* (MO-1904803); Alabama, *E.A. Smith s.n.* (US-956957, ex Biltmore Herbarium). Alabama, Tuscaloosa, *E.A. Smith s.n.* (F-99491, ex H. N. Patterson herbarium; MO-784596, ex Chapman estate from 1899 purchase by MO).

Herbaria (GH, MO, NY, UNA, and US) containing the best representation of collections from Chapman, Mohr, and Smith were searched for historical *Croton* collections. Five *Croton* specimens were located that bear evidence of having been seen by Chapman (i.e., bear writing in Chapman's hand), although additional specimens may turn up in his widely scattered exciccatae (see Stafleu and Mennega [1997] for a listing of the 27 herbaria with Chapman material). It is unclear whether the two sheets labeled "Tuscaloosa" by Chapman should be considered original material. If taken as a literal exact locality then the collections came from cultivated material and most likely post-date the preparation of the original description (i.e., post 1881). Smith did cultivate plants in Tuscaloosa that were eventually a source of specimens, but these were probably the small, valuable seedlings also received in the summer of 1881, and not likely to become herbarium fodder at that time. On the other hand, label locality data secondarily penned by Chapman and not the collector might be distorted or incomplete. Chapman did generalize that Pratt's Ferry was "near Tuscaloosa" (see below) or he may have referred to Smith being based in Tuscaloosa.

John Donnell Smith (1829–1928) corresponded with and received specimens from Chapman during at least 1884–1886, based on specimen provenance notations in Donnell Smith's hand and fragments of Chapman letters attached to herbarium specimens at US. Donnell Smith's personal herbarium (including the lectotype, see Figure 2 with embossed stamp) and library were donated to US in 1905. The lectotype has an attached undated fragment of a Chapman letter (consistent in the distinctive paper with other letter fragments established as dating from 1884-1886), presumably to Donnell Smith, that reads:

"*Croton Alabamensis* is not found along R[ail]Roads and being a shrub will remain pretty quiet in its secluded home near Tuskaloosa [sic]. Strange that it should be in flower every month from Sept to May through the coldest weather and yet they sent me specimens collected in all these months!"

Based on the detailed historical account given above, it appears that Chapman had material from two collectors (E.A. Smith and J. Hansberger), multiple dates and perhaps several Bibb County localities on hand for his original diagnosis. The circumstantial evidence (i.e., Smith did not visit the area between the time of the *Croton* discovery and publication, and he also refers to receiving specimens from a "correspondent") suggests that much of the material was collected by Jacob Hansberger near Tionis, and the lectotype may have been collected by him in April 1881 and sent to Smith, who forwarded the specimens to Chapman for description. The two branches on the lectotype sheet have young fruits at slightly different developmental stages and may come from separate late spring collections. Of the five sheets of original material, only the selected lectotype contains an additional printed label that indicates the specimen was associated with the "Flora of the Southern United States and Supplement" (i.e., Chapman 1883a).

In addition to sending duplicates to correspondents, Chapman sold sev-



FIG. 2. *Croton alabamensis* var. *alabamensis* (*E.A. Smith s.n.*: lectotype, US). Label data and fragment of letter in hand of A. Chapman. See text for transcription of letter.

eral sets of specimens that are massive enough to have been described as "herbaria." However, he always retained a personal working collection, the residue of which was purchased from his estate by MO in 1899. In 1896 Chapman selected and sold the best set of material on which his 1883 *Flora* was based, to the Biltmore Herbarium in Asheville, North Carolina. The Biltmore Herbarium, modeled after the Royal Botanic Gardens, Kew, was established ca. 1894 for George Vanderbilt (1862–1914) as a scientific adjunct to his lavish Biltmore Estate. At the time of the Chapman purchase, the herbarium was trying to establish itself as one of the foremost botanical institutions in the southern United States through purchasing and exchanging collections, hiring of collectors, and publishing the eponymous scientific journal *Biltmore Botanical Studies*. The enterprise withered after about 10 years of activity (peaking ca. 1901–1903) due to Vanderbilt's financial downturn and untimely death. A 1916 flood destroyed three-quarters of the collection and the residue of ca. 25,000 sheets was given to US in 1917. The Chapman collection was reportedly stored in a "vault" and largely salvaged (Maxon 1917; Boynton 1936). Only one flood-damaged fruiting specimen (US-956957, stamped ex Biltmore Herbarium) of *Croton alabamensis* clearly has this provenance and was used at the Biltmore in an illustration (see Lounsberry 1901:306). It is possible that other *C. alabamensis* specimens, including other type material at Biltmore, were destroyed.

An anomalous Tennessee record (Tullahoma, Coffee Co., 10 Aug 1899, *T. G. Harbison 725*, NCU-9391) has connections with Biltmore. Thomas Grant Harbison (1862–1936) was a member of the Biltmore Herbarium staff and made extensive collections of the southern flora. His incomplete Biltmore field notes deposited at US (partial number series of duplicate field notes bracketing, but not including, the *Croton* collection in question) place him in Tullahoma, but suggest errors on the specimen label which was made long afterwards (i.e., *Harbison 725* would have been collected on 12 Aug 1899 and not 10 Aug as reported with the specimen). A *Croton alabamensis* collection with the same collection number and from a well-established locality ("On sandstone bluffs along the Warrior River, Tuscaloosa, Alabama," *T. G. Harbison 725*, 11 Oct 1911, A) may have been a source of confusion. The credibility of the Tennessee record is doubtful.

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Book Review

Mark Turner and Phyllis Gustafson. 2006. **Wildflowers of the Pacific Northwest.** (ISBN 0-88192-745-7; 978-0-88192-745-0, flexibind). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax.). $27.95, 512 pp., 1248 color photos, 1221 maps, 31 line drawings, 5 3/4" × 8 1/4".

More than 1200 native and non-native species are described and illustrated, including 1247 color photos and 1219 range maps (indicating county distribution). The region covered is all of Washington and Oregon, plus southwestern British Columbia and the northern third of California. An ecoregions map and excellent summary intro chapter, "Climate, Geography, and Plant Habitats," set the stage. The photos are excellent, almost always showing flowers as well as critical vegetative features, and the morphological and ecological notes are brief and to the point. Six categories of flower color (white, yellow, orange, pink to red or red-purple, violet to blue or blue-purple, brown and green) provide the first division in the arrangement of species, followed within each color category by major structural features (e.g., number of petals, petals forming a tube or not, ovary inferior or superior, composite flowers). My perennial response to "color-coded" taxonomy is that so many people using this book will wish the blue- and white-flowered (etc.) species of a single genus were together, but apart from this personal bias, this book to me is a "third-generation" field guide, about as good as they get, useful to everyone interested in the flora of this region.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

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TWO NEW SPECIES OF *ELYMUS* (POACEAE) IN THE SOUTHERN U.S.A. AND OTHER NOTES ON NORTH AMERICAN *ELYMUS* SPECIES

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ABSTRACT

Two new species of *Elymus* L. are described, **E. churchii** J.J.N. Campb. and **E. texensis** J.J.N. Campb. *Elymus churchii* grows in the Ouachita and Ozark Mountains of Arkansas, Missouri and Oklahoma. It is similar to *E. svensonii* G.L. Church, but differs in its lemmas, which are usually pubescent, and have longer awns; its spikelets, which have fewer florets; its rachis internodes, which are longer, with hispid dorsal ridges and green longitudinal bands; and its foliage, which is typically less pubescent and less glaucous. *Elymus texensis* grows on the Edwards Plateau in southwest Texas. It is similar to *E. pringlei* Scribn. & Merr., but differs in its larger anthers; its glabrous lemmas; its larger spikelets; its longer spikes, with rachis internodes that are longer, with green longitudinal bands, and generally glabrous; and its foliage, which is sometimes densely pilose. The new species are known from few collections, and need much more study to assess their phylogentic status and geographic distribution. They are published here to allow inclusion in the Flora of North America, volume 24, and to stimulate further attention to them. Some additional notes and corrections are appended regarding the author's previous publications on *Elymus*.

RESUMEN

Se describen dos nuevas especies de *Elymus* L., **E. churchii** J.J.N. Campb. y **E. texensis** J.J.N. Campb. *Elymus churchii* vive en las montañas Ouachita y Ozark de Arkansas, Missouri y Oklahoma. Es similar a *E. svensonii* G.L. Church, pero se diferencia por sus lemas, que son usualmente pubescentes, y tienen aristas más largas; sus espiguillas, que tienen menos flores; sus internudos del raquis, que son más largos, con costillas dorsales híspidas y bandas verdes longitudinales; y su follaje, que es típicamente menos pubescente y menos glauco. *Elymus texensis* vive en el Edwards Plateau en el sureste de Texas. Es similar a *E. pringlei* Scribn. & Merr., pero difiere por sus anteras más grandes; sus lemas glabros; sus espiguillas más grandes; sus espigas más largas, con internados del caquis que son más largos, con bandas verdes longitudinales, y generalmente glabras; y su follaje, que es a veces densamente piloso. Las nuevas especies se conocen de pocas colecciones, y necesitan mucho más estudio para evaluar su estatus filogenético y distribución geográfica. Se publican aquí para que puedan incluirse en la Flora de Norte América, volumen 24, y para estimular la atención sobre ellas. Se añaden notas adicionales y correcciones a publicaciones previas del autor sobre *Elymus*.

INTRODUCTION

In 2002, I provided descriptions, specimen data, and distribution maps for two taxa of *Elymus* that seemed different from other members of the genus with paired spikelets and reduced or vestigial glumes (Campbell 2002a). I refrained

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then from formal taxonomic recognition, but after further revison I am now more confident. To allow inclusion in the Flora of North America, volume 24 (M.E. Barkworth et al., in prep.), I present below the two new names, and a key to the species of *Elymus* that have paired spikelets and reduced or vestigial glumes. There has been much uncertainty in the circumscription and phylogeny of these species, which would have been grouped together under the broad concept of *Elymus interruptus* Buckley by Hitchcock and Chase (1951).

Elymus churchii J.J.N. Camp., sp. nov. (**Fig. 1**). TYPE: U.S.A. ARKANSAS: Conway Co.: Petit Jean State Park, rocky bluffs, P.O. Morrilton, 1500 ft, 3 Jul 1957, *D. Demaree 37234* (HOLOTYPE: UARK; ISOTYPES: OKL, SMU-BRIT).

Affine *Elymo svensonii* G.L. Church sed differt lemmibus plerumque pubescentibus aristis (10–)20–30(–35) mm longis, spiculis flosculis 3(–5), internodis spicarum (5–)7–13(–18) mm longis viridi-vittatis dorsaliter hispidis, foliis paginis adaxialibus glabris vel pilosis, et plantis non glaucissimis.

Plants cespitose, often somewhat, but not strongly, glaucous. **Culms** 50–120 cm, erect; **nodes** usually 4–8, exposed or covered, often reddish-brown or blackish, glabrous. **Leaves** evenly distributed; **sheaths** usually glabrous, or sometimes pubescent at the summit; **auricles** 1–2 mm, often reddish brown or blackish; **ligules** up to 1 mm, often reddish-brown; **blades** 3–11 mm wide, lax, adaxial surfaces glabrous or short-pilose. **Spikes** 10–18 cm long, 3–5 cm wide, slightly nodding, with 2 spikelets per node; **internodes** (5–)7–13(–18) mm, about 0.2 mm thick at the thinnest sections, flexuous, with green longitudinal bands along the concave sides, glabrous except for the two hispid dorsal ridges; **disarticulation** below each floret, but not below the glumes. **Spikelets** usually appressed, 10–15 mm (excluding awns), with 3(–5) florets. **Glumes** often unequal (differing in length by more than 5 mm), or sometimes vestigial to absent from the upper spikelets or throughout, 0–15(–20) mm long including the undifferentiated awns, indurate at base, 0.1–0.3 mm wide, setaceous to subulate, with 0–1 distinct vein, glabrous, awns often outcurving; **lemmas** 8–10 mm, pubescent, or occasionally glabrous, awns (10–)20–30(–35) mm, slightly to (at maturity) strongly outcurving; **paleas** 7–9 mm, obtuse to truncate, or emarginate; **anthers** about 2.5–3 mm, evident in June. $2n$ = unknown.

Elymus churchii grows in dry rocky soils, often base-rich, in open woods on ridges, bluffs and river banks of the central Ouachita Mountains and the western Ozark Mountains, in Arkansas, Oklahoma and Missouri. It was previously included within a broad concept of *E. interruptus* (Steyermark 1963; Smith 1991). It is similar to *E. svensonii*, which is disjunct in Kentucky and Tennessee. It might reasonably be combined as a subspecies or variety of *E. svensonii*, but differs in its lemmas, which are usually pubescent, and have longer awns; its spikelets, which have fewer florets; its rachis internodes, which are longer, with hispid dorsal ridges and green longitudinal bands; and its foliage, which is typically less pubescent and less glaucous. It may have originated, like *E. svensonii*,

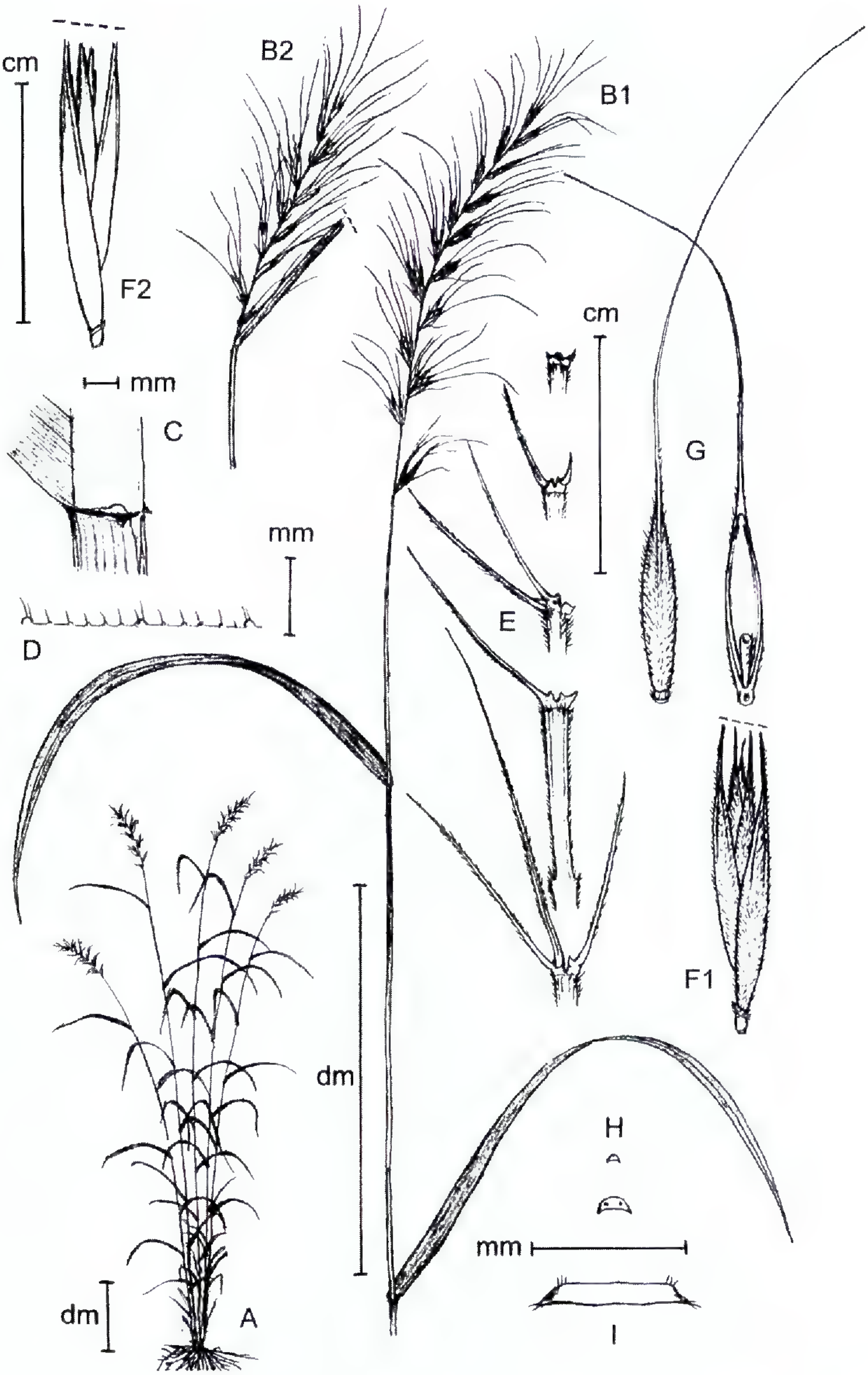


FIG. 1. *Elymus churchii* (drawn from *Demaree 29337* unless noted). **A.** Habit. **B.** Upper portion of culm with mature spike, viewed on plane with alternating spread of spikelets (B2 from *Palmer 57957*). **C.** Sheath summit and blade bases. **D.** Adaxial leaf surface, showing veins and hairs. **E.** Mature rachis internodes and glumes (showing variation in size), viewed in plane of spikelet spread (with abaxial view of central glume in spikelet, and largely side view of lateral glume). **F.** Spikelet, with lateral view of florets (F2 from *Palmer 57957*). **G.** Mature floret in abaxial view (left) and adaxial view (right). **H.** Cross-sections of mature, indurate glume bases (showing variation in size). **I.** Cross-section of central rachis internode.

from introgression of *E. canadensis* L. and *E. hystrix* L., and there are occasional specimens suggesting transitions to both species (Campbell 2002a). This species is named after George L. Church, who conducted several useful studies of *Elymus* in eastern North America, focusing on problems of hybridization and the species with reduced glumes (Church 1967).

PARATYPES: **ARKANSAS. Baxter Co.:** rocky shaded bluff, White Rv., P.O. Lakeview, Bull Shoals Dam Reservoir, 600 ft, 1 Jul 1950, *D. Demaree 29337* (OKL, TEX). **Logan Co.:** Magazine Mt., about 45 mi east of Fort Smith, 8 Aug 1942, *D.M. Moore 420118* (TEX), Sep 1947, *D.M. Moore 470639/642* (UARK, NCU, US), and 30/31 Jul 1949, *D.M. Moore 490422/441* (UARK). **Newton Co.:** Big Bluff above Buffalo Rv., 5 mi below Ponca, 5 Jun 1953, *D.M. Moore 53259* (UARK). **OKLAHOMA. Le Flore Co.:** Rich Mt., roadside, oak-pine dominant, 16 Jun 1940, *H. Taylor 110* (OKL); see also Campbell (2002a).

The only collection known from Missouri has relatively short rachis intenodes (ca. 5-7 mm): Christian Co., 3 miles west of Nixa, rocky wooded banks, 24 Jun 1954, *E.J. Palmer 57957* (SMU). I previously suspected that all of Steyermark's (1963) records of *Elymus diversiglumis* Scribn. & C.R. Ball or *E. interruptus* in Missouri could be grouped with the plants described here as *E. churchii* (Campbell 2002a). However, some of these records were based on misidentifications: *E.J. Palmer 66416* (UMO) is *E. glabriflorus* var. *australis* (Scribn. & C.R. Ball) J.J.N. Campb.; *E.J. Palmer 55939* (UMO) is *E. hystrix* var. *bigelovianus* (Fernald) Bowden.

Elymus texensis J.J.N. Camp., sp. nov. (**Figs. 2a, b**). TYPE: U.S.A. TEXAS. Gillespie Co.: Serpentine Mounds, about 9 mi N of Willow City, hilly area vegetated mainly with grasses, 18 May 1966, *E.S. Nixon 531* (HOLOTYPE: TEX 5322).

Affine *Elymo pringlei* Scribn. & Merr. sed differt antheris 4.5–6 mm longis, lemmibus glabris, spiculis 25–40 mm longis flosculis 5–8, spicis 9–20 cm longis internodis (5–)7–15(–22) mm longis viridi vittatis glabris praeter margines ciliolatos, foliis paginis adaxialibus dilute scabri-hirsutis vel dense brevipilosis.

Plants cespitose, glaucous. **Culms** 70–110 cm, erect; **nodes** usually 4–6, mostly exposed, glabrous. **Leaves** evenly distributed; **sheaths** glabrous; **auricles** about 0–1 mm, sometimes adherent to sheath summit, pale to purplish brown; **ligules** about 1 mm, erose; **blades** 2–9 mm wide, lax, or somewhat involute, adaxial surfaces thinly scabrous-hirsute or densely short-pilose. **Spikes** 9–20 cm long, 2–2.5 cm wide, erect to slightly nodding, with 2 spikelets per node; **internodes** (5–)7–15(–22) mm, about 0.1–0.3 mm thick at the thinnest sections, with slight dorsal ridges, with green longitudinal bands along the concave sides, glabrous except for the ciliolate margins; **disarticulation** below each floret, but not below the glumes. **Spikelets** appressed, 25–40 mm (excluding awns), with 5–8 florets (including terminal rudiment). **Glumes** subequal, 14–24 mm long including the undifferentiated awns, 0.1–0.3 mm wide, setaceous, with 0–1 distinct vein, glabrous, awns more or less straight; **lemmas** 8–12 mm, glabrous, awns 8–25 mm, straight, flexuous or slightly curving; **paleas** about 7–11 mm, obtuse or narrowly truncate; **anthers** 4.5–6 mm, evident in May. $2n$ = unknown.

Elymus texensis is known only from three collections that were made on calcareous bluffs and hills, in juniper woods and grassy areas on the Edwards Plateau of southwest Texas (Campbell 2002). It is similar to *E. pringlei*, but differs in its larger anthers; its glabrous lemmas; its larger spikelets; its longer spikes, with rachis internodes that are longer, with green longitudinal bands, and generally glabrous; and its foliage, which is sometimes densely pilose. It is notable that the northernmost known collection of *E. pringlei* appears somewhat atypical and may be transitional to *E. interruptus* or *E. texensis*: MEXICO, Coahuila, 54 mi SE of Big Bend National Park, south end of Sierra Maderas del Carmen, Canyon de la Fronteriza, ryolite area, *J. Henrickson 15045* (TEX). That collection has relatively robust glumes, long rachis internodes, spikelets with up to 6 florets (including the terminal rudiment), and lemmas that are virtually glabrous (Campbell 2002a). This new species is named after the great state of Texas.

PARATYPES: **TEXAS. Burnet Co.:** Inks Lake State Park, limestone bluffs, juniper woods along creek just east of HQ, 19 May 1983, *R. & G. Kral 70066* (VDB, SMU-BRIT). **Uvalde Co.:** chalk bluff on Nueces River, 12 May 1938, *V.L. Cory 29073* (US 3039432).

KEY TO *ELYMUS HYSTRIX* AND ITS ALLIES

These two new species appear to belong in a natural group with *Elymus hystrix* and other allies. The following key distinguishes the members of this group. Brief notes on ranges are inserted, but Campbell (2002a) should be consulted for maps and further details.

This group of species is characterized by their reduced or vestigial glumes, with 0–1(–2) veins, tapering from the base, 0–24 mm long including awns, often differing in length by at least 4 mm, 0.1–0.5(–0.7) mm wide, persistent after florets disarticulate; and by their rachis internodes usually 0.1–0.3 mm thick at the thinnest sections, often with green longitudinal bands along the concave sides. This group should be contrasted with the more heterogeneous group that consists of *E. virginicus* L., *E. canadensis* L., *E. glaucus* Buckley and their allies. The latter species have glumes with 2–5(–8) veins, widening or linear above the base, 4–45 mm long including awns, subequal, 0.2–2.3 mm wide, persistent or disarticulating; and rachis internodes usually 0.2–0.8 mm thick at the thinnest sections, usually lacking green bands. *Elymus interruptus* remains a somewhat problematic taxon, with specimens that can fit within either of these outlines. Moreover, various hybrids of *E. hystrix* with other species will fit within either outline, and will require deeper analysis. It is likely that some allies of *E. hystrix* in this group originated from hybridization (Church 1967; Campbell 2002a).

1. Spikelets widely divergent to perpendicular at maturity; lemma awns straight (rarely slightly curving); glumes vestigial or 1–3 mm long, occasionally some unequal glumes up to 10(–20) mm long and 0.1–0.2 mm wide but with no distinct vein; spikes more or less erect [widespread in eastern North America, but unknown in Texas] _____ **E. hystrix**

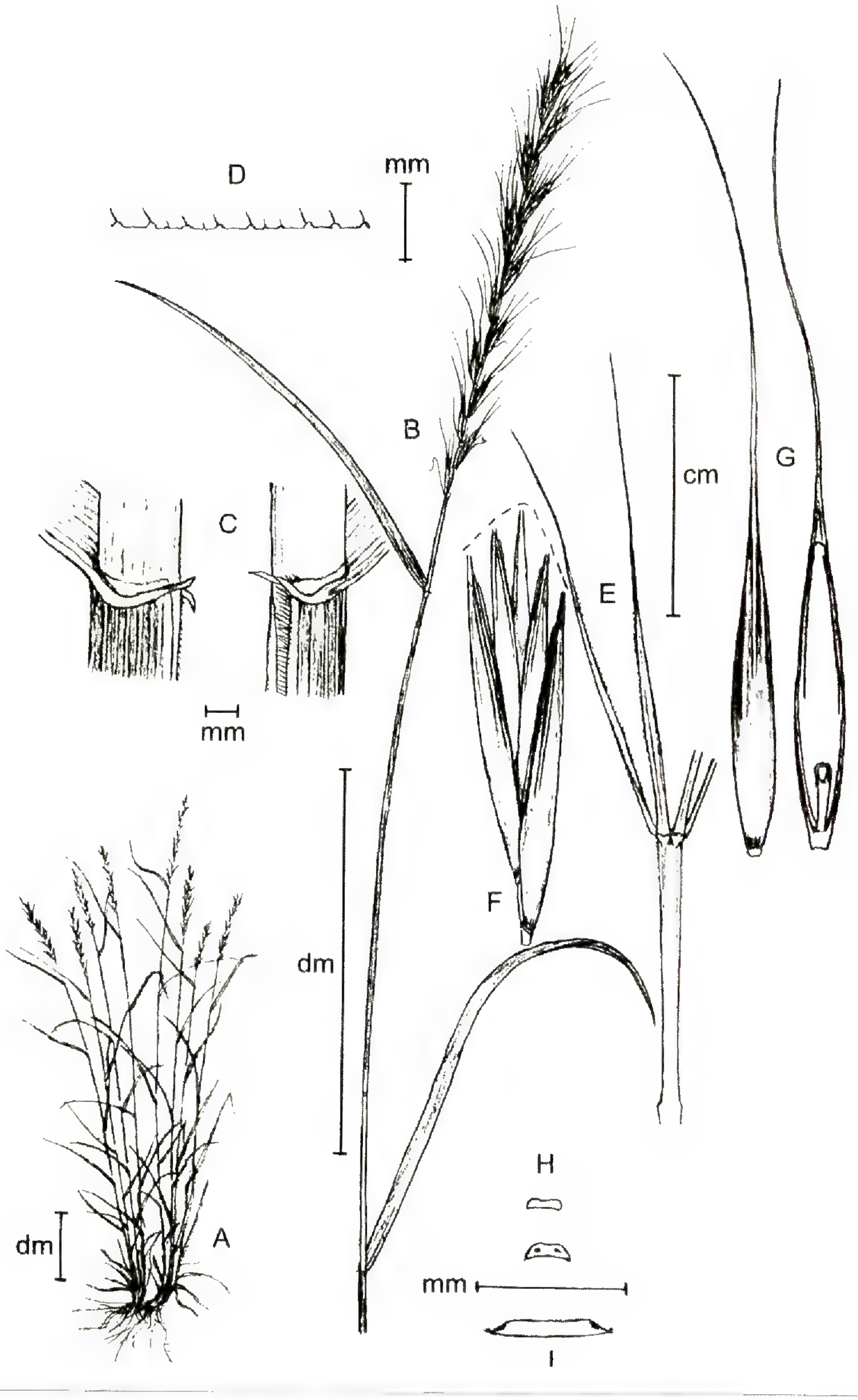


Fig. 2a. *Elymus texensis* (2a drawn from *E.S. Nixon 531*). **A.** Habit. **B.** Upper portion of culm with mature spike, viewed on plane with alternating spread of spikelets. **C.** Sheath summit and blade base. **D.** Adaxial leaf surface, showing veins and hairs. **E.** Mature rachis internode and glumes, viewed in plane of spikelet spread (with abaxial view of central glume in spikelet, and largely side view of lateral glume). **F.** Spikelet, with lateral view of florets. **G.** Mature floret in abaxial view (left) and adaxial view (right). **H.** Cross-sections of mature, indurate glume base(s). **I.** Cross-section of central rachis internode.

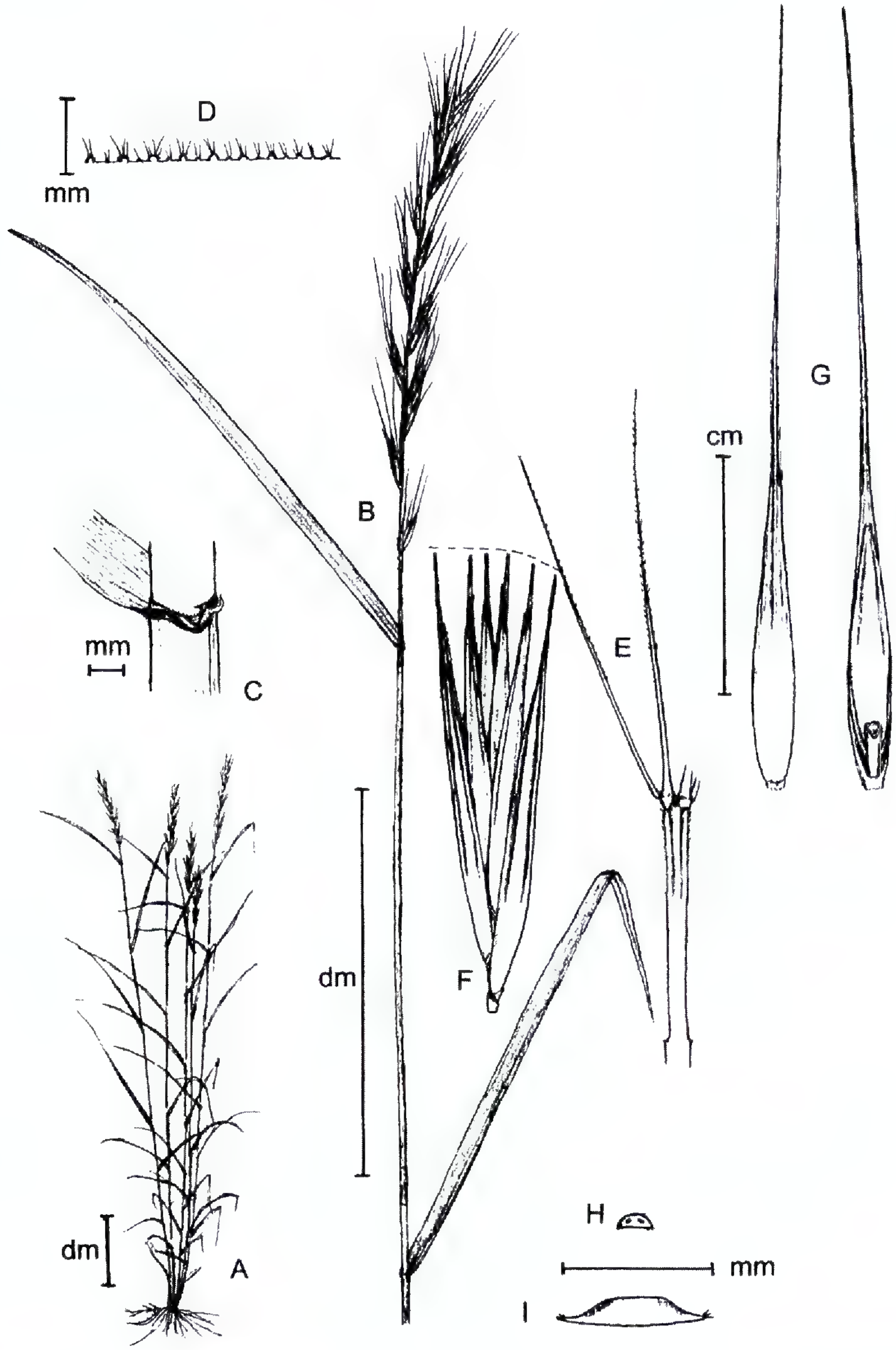


FIG. 2b. *Elymus texensis* (2b drawn from *V.L. Cory 29073*). **A.** Habit. **B.** Upper portion of culm with mature spike, viewed on plane with alternating spread of spikelets. **C.** Sheath summit and blade base. **D.** Adaxial leaf surface, showing veins and hairs. **E.** Mature rachis internode and glumes, viewed in plane of spikelet spread (with abaxial view of central glume in spikelet, and largely side view of lateral glume). **F.** Spikelet, with lateral view of florets. **G.** Mature floret in abaxial view (left) and adaxial view (right). **H.** Cross-sections of mature, indurate glume base(s). **I.** Cross-section of central rachis internode.

1. Spikelets usually appressed, never perpendicular; lemma awns straight or curving; glumes sometimes vestigial, but usually 1–24 mm long, 0.1–0.5(–0.7) mm wide, often with a distinct vein; spikes erect, nodding or pendent.
   2. All glumes well-developed, at least 12 mm long, subequal; lemma awns straight to moderately curving; spikes erect to slightly nodding.
      3. Spikelets (6–)9–15(–22) mm long (excluding awns), each with 2-5 florets; lemma awns moderately outcurving at maturity; glumes 0.2–0.5(–0.7) mm wide [in the southern Rocky Mountains and adjacent regions, from southern California to western Texas to northern Coahuila] _____ **E. interruptus**
      3. Spikelets 18-40 mm long (excluding awns), each with 3-8 florets; lemma awns straight to slightly curving at maturity; glumes 0.1–0.3(–0.6) mm wide.
         4. Anthers 2.5 4 mm long; lemmas scabrous hispid to thinly strigose-pubescent; spikelets 18 25 mm long, with 3–6 florets; spikes 4–12 cm long, rachis internodes 3–6 mm long, without green longitudinal bands, hispid on dorsal ridges; blades thinly scabridulous, hispidulous or pilose on veins [along the Sierra Madre Orientale, in eastern Mexico from Coahuila to Veracruz] _____ **E. pringlei**
         4. Anthers 4.5–6 mm long; lemmas glabrous; spikelets 25–40 mm long, with 5–8 florets; spikes 9–20 cm long, rachis internodes (5–)7–15(–22) mm long, with green longitudinal bands, glabrous except for ciliolate margins; blades thinly scabrous-hirsute to densely pilose [on the Edwards Plateau, in south west Texas] _____ **E. texensis**
   2. Some glumes less than 12 mm, each pair usually differing in length by at least 4 mm when developed, or one or both vestigial; lemma awns outcurving at maturity, often strongly so; spikes slightly nodding to pendent.
      5. Rachis internodes 4 6(9) mm long; glumes (0.1–)0.2–0.5(–0.6) mm wide; lemmas hirsute to strigose, at least near margins; sheaths glabrous; plants not glaucous to moderately glaucous [mostly in the northern Great Plains, from Saskatchewan to Ontario to Iowa] _____ **E. diversiglumis**
      5. Rachis internodes (4–)6–13(–18) mm long; glumes 0.1 0.3 mm wide; lemmas glabrous or pubescent; sheaths glabrous or villous; plants usually glaucous, sometimes strongly so.
         6. Lemmas usually pubescent, the awns (10–)20–30(–35) mm long; spikelets with 3(5) florets; rachis internodes (5–)7–13(–18) mm long, with green longitudinal bands and hispid dorsal ridges; blades glabrous or short-pilose; plants not strongly glaucous [central Ouachita and western Ozark mountains, in Arkansas, Missouri and Oklahoma] _____ **E. churchii**
         6. Lemmas glabrous, or occasionally hispidulous near apex, the awns (8–)10–20 (25) mm long; spikelets with (3-)4 5 florets; rachis internodes (4)6–10(–12) mm long, without green longitudinal bands, glabrous; blades usually villous; plants strongly glaucous [central Interior Low Plateaus, in Kentucky and Tennessee] _____ **E. svensonii**

OTHER NOTES

The taxonomy of *Elymus* in North America has a long tortuous history. In drafting a treatment of the species with paired spikelets, I have made some suggestions for nomenclature, which will hopefully guide botanists in their interpretation of these taxa (Campbell 1995, 1996, 2000, 2002a, 2002b, 2002c). However, it is clear that much deeper analysis is needed, including a proper focus at the

genetic level, instead of relying just on the rather inadequate morphological differences. There has been much taxonomic confusion, misidentification, and erroneous reporting of distributions. Many mysteries remain.

An Elymus hystrix-like collection from New Mexico

An anomalous collection that may have similarities to both *Elymus hystrix* and *E. interruptus* is of interest here: NEW MEXICO [Colfax Co.], Cimarron, wooded bank, 6 Jul 1939, *W.A. Silveus 4928* (TEX). This specimen was listed by Church (1967) under his "atypical" *E. hystrix* group with filiform glumes. Unfortunately all the florets are lost, but the glumes are narrower (ca. 0.2 mm) and more widely spreading than typical *E. interruptus*, and rachis internodes are shorter (ca. 5 mm). This specimen suggests that plants closely related to *E. hystrix* may still be found in northern New Mexico or nearby. The closest documented *E. hystrix* is in eastern Oklahoma. Does this New Mexico plant have a distinct origin, perhaps from some isolated introgressed population?

Elymus interruptus in California

I recently discovered the following specimen of *Elymus interruptus*: CALIFORNIA, Fresno Co., Pine Ridge, altitude 5300 ft, "Plants of the Sierra Nevada Mountains," 15-25 Jul 1900, *H.M. Hall & H.P. Chandler 317* (DOV). This collection was initially annotated as *E. canadensis*. It appears to be the first record of *E. interruptus* from California. The few other records of *E. canadensis* from the state should be checked.

Need to clarify typification of Elymus virginicus

Some of the Linnaean material of *Elymus virginicus* does not clearly match our current typical concept of that species, and should probably be included with *E. glabriflorus* (Vasey ex L.H. Dewey) Scribn. & C.R. Ball. I proposed to the International Association for Plant Taxonomy that the name *E. virginicus* be retained for the typical plants of Hitchcock and Chase (1951) and most other authors, with a new type established for that species (Campbell 1996). However, more careful analysis of the several sheets of Linnaean material is needed, and the Nomenclature Committee remains undecided (D. Nicholson & R. Soreng, pers. comm.). After the treatment in Flora of North America is published, there will undoubtedly be further consideration of this problem, and I hope to revive the proposal with more evidence.

Corrections to Campbell (2002b)

(a) In the key, leads (number 13 & 14) to *E. glaucus*, *E. hirsutus* J. Presl. and *E. dahuricus* Turcz. ex Griseb. will be modified substantially for the Flora of North America. *E. dahuricus* is a rare Asian introduction that appears close to *E. hirsutus*; its lemmas can be glabrous, not just scabrous or hispid, as stated in the key.
(b) In the key, the lead (number 15) to *E. interruptus* versus *E. canadensis* and *E. wiegandii* Fernald should omit the spike internode thickness character, which reflected some erroneous data.

(c) By priority, the correct name for *Elymus submuticus* (Hook.) Smyth & Smyth is *E. curvatus* Piper.

ACKNOWLEDGMENTS

I am deeply grateful to Mary E. Barkworth, who has provided continual encouragement and constructive advice during the 20 years that I have dabbled eccentrically in *Elymus*. Without her invitation to contribute to the Manual of Grasses, and then the Flora of North of America, my efforts would not have progressed. She provided insightful comments on an earlier draft of this manuscript. I am grateful also to Kathleen M. Capels, who corrected several errors and inconsistencies in the key and pointed out the priority of *E. curvatus*.

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A NEW HYBRID GENUS AND 12 NEW COMBINATIONS IN NORTH AMERICAN GRASSES

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ABSTRACT

One new hybrid genus, ×**Pascoelymus** = *Pascopyrum* × *Elymus*, and 12 new combinations are presented for North American grasses. Six of the new combinations are for hybrids in the *Triticeae*. *Stipa arnowiae* is transferred to *Achnatherum* and *Hystrix californica* (≡ *Elymus californicus*) to *Leymus*. *Agropyron riparium* is recognized as a subspecies of *Elymus lanceolatus*; *Ammophila champlainensis* is reduced to a subspecies, based on the findings of others, and the previously recognized subspecies of *Pseudoroegneria spicata* are reduced to forms. Reasons for the changes are provided.

RESUMEN

Se presenta un nuevo género híbrido, ×**Pascoelymus** = *Pascopyrum* × *Elymus*, y 12 combinaciones nuevas de gramíneas norteamericanas. Seis de las nuevas combinaciones son de híbridos en *Triticeae*. *Stipa arnowiae* se transfiere a *Achnatherum* y *Hystrix californica* (≡*Elymus californicus*) a *Leymus*. *Agropyron riparium* se reconoce como una subespecie de *Elymus lanceolatus*; *Ammophila champlainensis* se reduce a una subespecie, basándonos en los hallazgos de otros, y la subespecie reconocida previamente de *Pseudoroegneria spicata* se reduce a formas. Se aportan razonamientos de los cambios.

INTRODUCTION

Volume 24 in the *Flora of North America* series will be the second of the two volumes on grasses. Its completion requires publishing the following 12 names. Eleven of the 12 new combinations are for previously recognized taxa; one is a new hybrid genus.

Six of the new combinations, and the new genus, are for hybrids in the *Triticeae*. Identifying the parents of hybrids without knowing which species were present in the vicinity is always difficult. In most instances, I have accepted the parentage suggested by previous workers when naming these taxa; in one instance, I have felt compelled to disagree. The known distribution of many of these hybrids is limited. The remaining six names affect non-hybrid taxa. Two reflect a generic change and four a change in rank.

I have attempted to examine type material of all the taxa treated. As indicated below, however, this has not always been possible. All the taxa mentioned will be described and illustrated in the *Flora of North America* volume 24. The

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illustrations will also be available at http://herbarium.usu.edu/webmanual/. To the extent permitted by the institutions that own them, photographic images of the type specimens examined are also available via this site and will be available via TROPICOS. The images include close ups of individual parts in addition to images of the whole specimen.

NOMENCLATURAL TREATMENT

POEAE

Ammophila breviligulata subsp. **champlainensis** (F. Seym.) Walker, Paris & Barrington ex Barkworth, comb. nov. BASIONYM: *Ammophila champlainensis* F. Seym., Sida 2:349. 1966. TYPE: U.S.A. NEW YORK: Lake Champlain, Au Sable Point, in sand, 3 Jul 1902, *Nellie F. Flynn s.n.* (HOLOTYPE: VT).

Walker, Paris, and Barrington (1998) reported that *Ammophila breviligulata sensu stricto* Fern. and *A. champlainensis* differ completely in glume length and flowering time, and tend to differ in inflorescence length. They noted, however, that the morphological and molecular uniformity of *A. champlainensis*, combined with the prevalence of vegetative reproduction in both taxa, is consistent with the hypothesis that all populations of *A. champlainensis* are derived from a single genetic individual. For this reason, they recommended acknowledging the distinction between the two taxa at the subspecific, rather than specific level. I present the new combination here so that it may be used in volume 24 of the *Flora of North America*.

STIPEAE

Achnatherum arnowiae (S.L. Welsh & N.D. Atwood) Barkworth, comb. nov. BASIONYM: *Stipa arnowiae* S.L. Welsh & N.D. Atwood, *Utah Fl.* (ed. 3):799. 2003. U.S.A. UTAH. Kane Co.: T43S, R4W, S 13, ca 19 mi E of Johnson Canyon Jct; pinyon-juniper-sagebrush-community at 1740 m, on white, gypsiferous member of the Moenkopi Formation, 30 May 2001, *S.L. Welsh & T. O'Dell 28062* (HOLOTYPE: BRY; ISOTYPE UTC-245001!).

This taxon is very similar to *Achnatherum hymenoides* (Roem. & Schult.) Barkworth, differing in having loosely contracted panicles with non-divaricate branches.

TRITICEAE

×**Elyleymus hultenii** (Melderis ex Hultén) Barkworth, comb. nov. BASIONYM: ×*Agroelymus hultenii* Melderis ex Hultén, Ark. Bot., n.s. 7(1):21. 1968. *Agropyron alaskanum* var. *arcticum* Hultén, Acta Univ. Lund., n.s. 38: 257. 1942. TYPE: U.S.A. ALASKA: Deering, *J.P. Anderson* 4790 (HOLOTYPE: ALA!).

Hultén (1968) listed the parents of this hybrid as *Agropyron boreale* subsp. *alaskanus* (Scribn. & Merr.) Melderis and *Elymus arenarius* subsp. *mollis* (Trin.) Hultén. The new combination is needed because these two species will be treated as *E. alaskanus* (Scribn. & Merr.) Á. Löve subsp. *alaskanus* and *Leymus mollis* (Trin.) Pilger, respectively, in the *Flora of North America* vol. 24.

Although Hultén (1968) listed Melderis as the author of the name ×*Agroelymus hultenii*, he did not explain Melderis' contribution in the article. For this reason, the authorship is "Melderis ex Hultén" rather than "Melderis in Hultén". If using short form citations, it would be Hultén.

×**Elyleymus ontariensis** (Lepage) Barkworth, comb. nov. BASIONYM: ×*Agroelymus ontariensis* Lepage, Nat. Can. 79:254–257. 1952. TYPE: CANADA. Ontario: James Bay, Riv. Attawapiskat, 21 Aug 1946, *A. Dutilly & E. Lepage 16,423* (HOLOTYPE: originally deposited in LCU, transferred to NA, then to US. Despite a search at both NA and US, it has not been located).

×*Elyleymus ontariensis*, according to Bowden (1967), comprises hybrids between *Elymus trachycaulus* (Link) Gould ex Shinners [≡ *Agropyron trachycaulum* (Link) Malte ex H.F. Lewis] and *L. innovatus* (Beal) Pilger [≡ *Elymus innovatus* Beal]. Bowden regarded it as a synonym of ×*Elyleymus hirtiflorus* (Hitchc.) Barkworth & D.R. Dewey, but the holotype of that hybrid grows outside the range of *L. innovatus*. It is interpreted as having *Leymus simplex* (Scribn. & T.A. Williams) D.R. Dewey as the *Leymus* parent.

×**Elyleymus mossii** (Lepage) Barkworth, comb. nov. BASIONYM: ×*Agroelymus mossii* Lepage, Nat. Canad. 92:214–215. 1965. TYPE: CANADA. Alberta: Near Lake Louise, in open woods, 22 Aug 1946, *E. H. Moss 7257* (HOLOTYPE: ALTA 1044!).

The proposed combination reflects a difference of opinion concerning the parents of this hybrid as well as a difference in generic interpretation. Lepage (1965) stated that it was obvious that *Elymus canadensis* L. was one parent of this hybrid, but that it would be necessary to discover which species of *Agropyron* [in the traditional sense] grew in the neighborhood to determine the other parent. He gave "*Agropyron* (?) *trachycaulum*" as a possibility. Boivin (1967) agreed that *E. canadensis* but suggested that the *Agropyron* parent was *Agropyron violaceum* (Hornem.) Lange [≡ *Elymus violaceus* (Hornem.) Feilberg].

Elymus canadensis, however, is generally absent from the region around Lake Louise (Moss 1983), the area where the holotype was collected. Other features of the holotype that are difficult to reconcile with Lepage's suggested parentage are the presence of rhizomes and the abundance of relatively long soft hairs on both the lemmas and the glumes. *Elymus canadensis* is not rhizomatous, has coarse hairs on the lemmas, and has scabrous rather than hairy glumes. *Elymus trachycaulus* and its high elevation counterpart, *E. alaskanus* subsp. *latiglumis* (Scribn. & J.G. Sm.) Á. Löve, usually lack rhizomes, and have glabrous or shortly hairy lemmas and glumes. More probable parents are *Elymus glaucus* Buckley and *Leymus innovatus*, both of which are common in the region. *Elymus glaucus* has spikes that more closely resemble the holotype in their posture, thickness, and awn length than those of *E. canadensis*; *L. innovatus* has soft hairs on its glumes and lemmas. *Elymus glaucus* is sometimes shortly rhizomatous; *Leymus innovatus* is always rhizomatous. Based on this interpretation of the parentage, the hybrid has to be included in ×*Elyleymus*.

Elymus ×cayouetteorum (Boivin) Barkworth, comb. nov. BASIONYM: ×*Agrohordeum cayouetteorum* Boivin, Nat. Canad. 94:520. 1967. TYPE: QUE!

Boivin (1967) published this name for hybrids between *Elymus trachycaulus* [≡ *Agropyron trachycaulum*] and *E. canadensis*.

Elymus lanceolatus subsp. **riparius** (Scribn. & J.G. Smith) Barkworth, comb. & stat. nov. BASIONYM: *Agropyron riparium* Scribn. & J.G. Smith, Bull. Div. Agrostol., U.S.D.A. 4:35. 1897. TYPE: U.S.A. MONTANA: Garrison, 10 Jul 1895, *P.A. Rydberg 2127* (LECTOTYPE: US 556672!, designated by Hitchcock 1935:776).

After examining many specimens, I agree with Dorn (1988) that this taxon merits recognition but prefer to treat it as a subspecies rather than a variety. It is more common than *Elymus lanceolatus* (Scribn. & J.G. Sm.) Gould subsp. *lanceolatus*.

×**Leydeum littorale** (H.J. Hodgs. & W.W. Mitch.) Barkworth, comb. nov. BASIONYM: ×*Elymordeum littorale* H.J. Hodgs. & W.W. Mitch., Canad. J. Bot. 43:1355. 1965. TYPE: U.S.A. ALASKA: Matanuska Valley, in tidal flat area along Cottonwood Creek near juncture with Knik Arm about 18 mi SW of Palmer, 2 Sep 1964, *W.W. Mitchell & H.J. Hodgson 1584* (HOLOTYPE: ALA 29247!).

×*Leydeum littorale* consists of hybrids between *Leymus mollis* and *Hordeum brachyantherum* Nevski. It has been collected in the Matanuska Valley, Alaska, and on the coast of Vancouver Island, British Columbia and it may be more widespread. Hodgson and Mitchell (1965) stated that it grows along the margins of the high-tide zone, where tidal waters flow into the creek. The hybrid plants can easily be distinguished from *L. mollis* by their shorter narrower spikes and more yellow and dense foliage. The new combination reflects recognition of the segregate genus *Leymus*.

Leymus californicus (Bol. ex Thurber) Barkworth, comb. nov. BASIONYM: *Gymnostichum californicum* Bol. ex Thurber in S. Watson, Bot. California 2:327. 1880. *Gymnostichum californicum* Bol. ex Thurb., Bot. California 2:327. 1880. *Hystrix californica* (Bol. ex Thurb.) Kuntze, Revis. Gen. Pl. 2:778. 1891. TYPE: *Elymus californicus* (Bol. ex Thurb.) Gould, Madroño 9(4):127. 1947. U.S.A. CALIFORNIA: Redwoods, near San Francisco, *H.N. Bolander s.n.* (LECTOTYPE: GH-19493!, designated by Baden, Frederiksen & Seberg, Nordic J. Bot. 17:457. 1997).

Transfer of this taxon to *Leymus* is supported by its chromosome number of $2n = 56$, and genome-specific RAPD assay results (Jensen & Wang 1997). It is consistent with Mason-Gamer's (2001) examination of granule-bound starch synthase genes in allotetraploid *Triticeae*. In her tree, it groups with *Psathyrostachys*, Nevski, a genus very close to *Leymus* (Bödvarsdóttir and Anamthawat-Jónsson 2003). Morphological characteristics that tend to place it in *Leymus* rather than *Elymus* include its well-developed rhizomes and the more or less equally prominent veins in its leaf blades. There are also many specimens of *L. innovatus*, particularly those from Alaska and Yukon Territory, that lack or have very reduced glumes.

The habitat of *L. californicus*, coniferous forests on non-alkaline soils, is unusual among North American species of *Leymus*. It is, however, similar to that of some Chinese species that are currently included in *Hystrix* Moench because of their lack of glumes.

Hitchcock (1935, 1951) and Baden et al. (1997) included *Leymus californicus* in *Hystrix* because it lacks glumes. The type of *Hystrix* is, however, *Elymus hystrix*, a species that, apart from lacking glumes and having strongly divergent spikelets, is morphologically, genomically, and molecularly similar to other eastern North American species of *Elymus*.

×**Pascoleymus** Barkworth, gen. hybr. nov. = *Pascopyrum* Á. Löve × *Leymus* Hochst. TYPE: *Pascoleymus bowdenii* (Boivin) Barkworth.

×**Pascoleymus bowdenii** (Boivin) Barkworth, comb. nov. BASIONYM: ×*Agroelymus bowdenii* Boivin. Nat. Canad. 94:520. 1967. TYPE: CANADA. ALBERTA: Beaverlodge, 19 Jul 1921, *M.O. Malte 108211* (HOLOTYPE: QFA!).

×*Agroelymus bowdenii* applies to hybrids between *Agropyron smithii* Rydb. [≡*Pascopyrum smithii* (Rydb.) Á. Löve] and *Elymus innovatus* [≡ *Leymus innovatus*] (Boivin 1967). Recognition of the genus *Pascopyrum* requires a new intergeneric hybrid name as well as a new combination at the species level.

Pseudoroegneria spicata f. **inermis** (Scribn. & J.G. Sm.) Barkworth, comb. nov. & stat. nov. BASIONYM: *Agropyron divergens* var. *inerme* Scribner & J.G. Sm., Bull. Div. Agrostol. U.S.D.A. 4[5]:27. 1897. TYPE: U.S.A. IDAHO: 1895, *L.F. Henderson 3058* (LECTOTYPE: US-556676!, Hitchcock 1935:773).

Daubenmire (1939, 1960) reported that rhizome development and awn length in *Agropyron spicatum* (Pursh) Scribn. & J.G. Sm. [≡ *Pseudoregoegneria spicata* (Pursh) Á. Löve] varied continuously within plants grown from seed. He concluded that the ability to produce rhizomes and unawned plants is heritable, that the two characters are not linked, and that which form becomes dominant at a local site is determined by environmental conditions.

Plant breeders working with *Pseudoroegneria spicata* consider that awn presence is determined by a single major gene, modified by some minor genes, with the unawned condition being dominant. Although no one has gathered the data that explicitly tests this hypothesis, extensive work with both awned and unawned accessions of the species suggests that it is true. It means that a pair of heterozygotic unawned parents will give rise to around 50% awned offspring. This hypothesis is consistent with Daubenmire's observations.

The above observations make it clear that the awned (*P. spicata* f. *spicata*) and unawned (*P. spicata* f. *inermis*) phases of *Pseudoroegneria spicata* are of little taxonomic significance despite their evident morphological difference. The reason for making names available at the level of form is to accommodate those who wish to distinguish the two entities.

Pseudoroegneria spicata f. **pubescens** (Elmer) Barkworth, comb. nov. & stat. nov.

BASIONYM: *Agropyron spicatum* var. *pubescens* Elmer, Bot. Gaz. 36:52. 1903. *Agropyron spicatum* subsp. *puberulentum* Piper, Contr. U.S. Natl. Herb. 11:147. 1906, *nom. superfl.* TYPE: U.S.A. WASHINGTON: Kittitas Co.: Mt. Stuart, Jul 1898, *A.D.E. Elmer 1158* (HOLOTYPE: Deposited in Stanford Herbarium which has been transferred to CAS; despite a search, it could not be located at CAS; ISOTYPE: US-1817092!).

Plants of *Pseudoroegneria spicata* with densely pubescent leaves are known from the east slope of the Cascade Mountains in Washington. Because plants with nearly as densely pubescent leaves are found elsewhere in southern Washington and northeastern Oregon, it seems best to recognize them as a form, *P. spicata* f. *pubescens*, commensurate in this respect with the level of recognition given the awned and unawned phases.

Publication of the above combinations automatically generates ***Pseudoroegneria spicata*** (Pursh) Á. Löve f. ***spicata*** with priority dating from 1814, the year of publication of the basionym for the specific epithet.

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Book Review

Ann Lindsay and Syd House. 2005. **The Tree Collector: The Life and Explorations of David Douglas. (Paperback Edition).** (ISBN 1-84513-052-9, pbk.). Aurum Press, 25 Bedford Ave., London WC1B 3AT, UK, distributed by Trafalgar Square, (**Orders:** 802-457-1911, 802-457-1913 fax, www.trafalgarsquarebooks.com). $16.00, 256 pp., appendices, bibliography, index, b&w photos, figures and maps, 5" × 7 3/4".

The book The Tree Collector by Lindsay and House allows readers to experience the excitement and adventures of botanical expeditions of David Douglas, the Scotsman for which the Douglas fir tree was named. The authors have woven a wonderful story of the botanical work of David Douglas by interlacing history and background information with David Douglas's own journal excerpts. Lindsay and House's efforts have created a book in which one really feels as though they are along for the journey.

Douglas's collection expeditions for the Horticultural Society occur after Lewis and Clark's journeys (1804–1806) and before any major Indian Wars (~1840). Douglas's own words and journal entries are the foundation of the story. Readers get wonderful descriptions of Douglas's impressions of plants, animals, landscape and climate in the Eastern United States, Canada, Pacific Northwest, California and Hawaii as well as insightful information on the indigenous peoples he encounters along his expeditions. Douglas's journal entries also include hardships with weather, illnesses, triumphs and disappointments in his collections, and the outcome of his return to London, which make this book all the more real for the reader. Truly engaging are stories of Douglas's excitement in hunting down plants of his particular interest such as the sugar pine.

The book includes an introduction of the family history of David Douglas and how he came to be a member of the Horticultural society, the group that supported Douglas's expeditions. Great care is taken in providing details of Douglas's expedition and discoveries throughout North America and Hawaii. Along with Douglas' journal entries, black and white line maps and images are included to help readers orient themselves with locations discussed. Appendices included in the text are excellent summaries of information on Douglas's botanical contributions to science, such as species introduced and those named after Douglas (common and specific epithet are included). Two appendices summarize David Douglas trails in Scotland, North America and Hawaii. Interestingly, appendices that discuss Douglas's botanical introductions often include short descriptions of the plant from Douglas's journal, as well as the authors' information on range or other factual information.

Take a journey with David Douglas into the wilds of North America and discover new plants, animals, and peoples.... pick up a copy of The Tree Collector today!—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

QUADRUPLE, TRIPLE, DOUBLE, AND SIMPLE PAPPI IN THE GOLDENASTERS, SUBTRIBE CHRYSOPSIDINAE (ASTERACEAE: ASTEREAE)

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ABSTRACT

Pappus variation in eight genera, 58 species, and 94 taxa of the Chrysopsidinae was examined; quadruple, triple, double and sometimes simple pappi were found with variation in the size, shape and numbers of short outer scales/bristles and mid to long barbellate bristles. In the genera with a higher chromosome base number ($x = 9$)—*Heterotheca*, *Noticastrum*, *Pityopsis*, and probably *Tomentaurum*—pappus elements are more numerous and in a greater number of series. This is interpreted as the primitive condition, similar to, but with less clavate inner bristles, than found in *Doellingeria* and *Eucephalus*, the basal genera in the North American Clade of the Astereae. All four genera have a quadruple pappus consisting of four, sometimes intergrading, series: a short secondary outer series of scales or scaly bristles; a secondary inner series of mid-length tapered bristles; a primary outer series of tapering bristles 80–95% the length of the inner series; and a primary inner series of usually weakly clavate bristles. Both ray and disc florets have a similar arrangement, except for the epappose ray fruits of *H.* sect. *Heterotheca*. In some species, the four series are distinct and in others they grade into each other. In *Croptilon*, the number of pappus series decreases with the dysploid reduction from $x = 7$ to $x = 4$. In the lower base number genera *Bradburia*, *Chrysopsis*, and *Osbertia*, a reduction in the number of series was observed, with quadruple, triple, double and sometimes simple pappi occurring. In *Chrysopsis*, the secondary outer series is well developed, but the secondary inner series is absent or reduced to a few bristles. In *Osbertia*, the pappus appears simple or includes a second series of 1–2 short bristles; all the long bristles are tapering or at best only very weakly clavate. In small sample per species, the number of bristles per fruit ranged from 20–125: *Noticastrum*, 46–125 averaging 87 bristles; *Tomentaurum*, 80–85; *Heterotheca*, 23–80 averaging 43 bristles; *Pityopsis*, 25–46, averaging 37; *Bradburia*, ray florets, 30–36, discs 0–5; *Chrysopsis* and *Croptilon*, 18–36 averaging 28; *Osbertia*, 20–35, averaging 27. The fruits with lower numbers of bristles had 0–few mid-length secondary inner series bristles.

RESUMEN

Se examinó la variación el vilano en ocho géneros, 58 especies, y 94 taxa de Chrysopsidinae; se encontraron vilanos cuádruples, triples, dobles y a veces simples con variación en el tamaño, forma y números de las escamas cortas externas y las sedas barbeladas medias a largas. En los géneros con un número cromosomático básico más alto ($x = 9$)—*Heterotheca*, *Noticastrum*, *Pityopsis*, y probablemente *Tomentaurum*—los elementos del vilano son más numerosos y están en mayor número de series. Esto se interpreta como una condición primitiva, similar pero con menos sedas interiores clavadas de las que se encuentran en *Doellingeria* y *Eucephalus*, los géneros basales del clado norteamericano de las Astereae. Los cuatro géneros tienen un vilano cuádruple que consta de cuatro series, a veces intergradadas: una serie corta secundaria de escamas o sedas escamosas; una serie secundaria interna

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de sedas afiladas de longitud media; una serie primaria externa de sedas afiladas del 80–95% de la longitud de la serie interna; y una serie primaria interna de sedas normalmente clavadas. Tanto las flores radiadas como las del disco tienen una ordenación similar, excepto los frutos sin vilano de *H.* sect. *Heterotheca*. El algunas especies, las cuatro series son distintas y en otras se intergradan entre ellas. En *Croptilon*, el número de series del vilano decrece con la reducción disploide de x =7 a x = 4. En los géneros con número base inferior *Bradburia*, *Chrysopsis*, y *Osbertia*, se ha observado una reducción en el número de series, con vilanos cuádruples, triples, dobles y a veces simples. En *Chrysopsis*, la serie secundaria externa está bien desarrollada, pero la serie secundaria interna está ausente o reducida a unas pocas sedas. En *Osbertia*, El vilano es simple o incluye una segunda serie de 1–2 sedas cortas; todas las sedas largas son afiladas o como mucho sólo débilmente clavadas. En una pequeña muestra por especie, el número de sedas por fruto varió entre 20–125: *Noticastrum*, 46–125 con una media de 87 sedas; *Tomentaurum*, 80–85; *Heterotheca*, 23–80 con una media de 43 sedas; *Pityopsis*, 25–46, con una media de 37; *Bradburia*, flores radiadas, 30–36, del disco 0–5; *Chrysopsis* and *Croptilon*, 18–36 con una media de 28; *Osbertia*, 20–35, con una media de 27. Los frutos con menor número de sedas tuvieron 0–few en la serie secundaria interna de longitud media.

INTRODUCTION

Goldenaster genera in the subtribe Chrysopsidinae Nesom (Asteraceae: Astereae) have long been reported to have a double pappus consisting of a short outer whorl of narrow to broad scales or linear bristles (e.g., Gray 1884; Fernald 1950; Cronquist 1968, 1980; Semple 1981, 1996; Semple & Bowers 1985; Semple et al. 1988). Nesom (1994a) in his protologue to subtribe Chrysopsidinae described the pappus as "2–3(–4)-seriate, persistent, the inner of 1–2 series of generally flattened bristles, outer of much shorter setae, bristles, or scales," but did not elaborate as to the number of series in each genus. Nesom (2000) described the pappi of the North American genera as follows: *Croptilon*, "pappus a single series of persistent, thick and rigid, equal-length, tawny to reddish-brown capillary bristles"; *Chrysopsis* (including *Bradburia*), "pappus in 2 series, the outer very short bristles, the inner of long capillary bristles"; *Heterotheca*, "pappus of tawny to whitish barbellate bristles somewhat uneven in length, with a shorter, outer series of lanceolate scales or bristle-like squamellae" and noted the epappose to few bristled ray floret cypselae of sect. *Heterotheca*; *Osbertia*, "pappus uniseriate, with numerous, nearly non-barbellate bristles, a short, outer series commonly present in *O. chihuahuana*"; *Pityopsis*, "pappus 2–seriate, the inner of barbellate bristles, the outer of much shorter setiform bristles or setae"; and *Tomentaurum*, "pappus of 45–60 white, barbellate bristles in several series, with a few inconspicuous setae or very slightly widened bristles, 0.5–1.5 mm long." Nesom (1994a, 2000) did not indicate which taxa had the flattened inner bristles. *Noticastrum* is native to South America and was not discussed in Nesom (2000). Zardini (1985) monographed the genus and described the pappus as being in two series, the external morphologically similar to the internal but of short bristles, normally straw-colored or reddish [five species] to purplish in *N. diffusum* and the bristles barbellate especially distally. Zardini also noted that the cypsela body was glandular in some taxa.

Many other North American Astereae have been reported to have a simple pappus. Some asters often treated in *Aster* sensu lato have been reported to have a "double" pappus (*Eucephalus* Nutt., *Sericocarpus* Nees: Gray 1884; Cronquist 1955) or a "triple" pappus (*Doellingeria* Nees: Cronquist 1968, 1980; Nesom 1994a,b; Semple et al. 2002). The "triple" pappus reportedly had two inner whorls, the outer slightly shorter and tapering and the inner bristles clavate. However, Hood and Semple (2003) demonstrated that nearly all species of goldenrods, which had been reported to have a simple pappus, in fact had a double pappus with two primary series of long bristles (the outer shorter and tapering, the inner clavate) and at least some species had a secondary outer series of a few very short bristles, i.e. *Solidago* has a double or triple pappus. Semple and Hood (2005) demonstrated that many North American aster genera have a double, triple, or quadruple pappus and concluded that the likely primitive pappus of the North American Astereae consists of four series: the primary inner series of long, clavate (flattened) bristles, a slightly shorter primary outer series of long tapering bristles, a secondary inner series of tapering bristles 40–80% the length of the primary inner bristles, and a secondary outer series of short bristles or narrow to broad squamellae usually only 10–15% the length of the inner primary bristles. Hood and Semple (2003) proposed a terminology for a triple pappus, i.e. secondary outer whorl, primary outer whorl, and primary inner whorl bristles, which Semple and Hood (2005) modified to cover the discovery of a fourth series of bristles found in asters but not seen in goldenrods. They also noted that "series" was a more accurate label than "whorl" based on observations of both North American and Old World aster genera. They concluded that due to the subtlety of the differences between the longer bristle series in many species, it would be practical to treat the pappus of *Symphyotrichum* as "appearing simple" in keys to identification. The details of the "double pappus" of the Chrysopsidinae were re-examined in light of the recent discoveries on pappus traits of goldenrods and asters and the results are presented in this paper.

MATERIALS AND METHODS

A preliminary survey was undertaken to examine the pappus of one or two specimens of representative species of the genera of the Chrysopsidinae sensu Nesom (2000). Subsequently, a more detailed survey was conducted involving eight genera, 58 species, and 94 taxa of subtribe Chrysopsidinae listed in Table 1. Observations were made using a dissecting scope (10–70×) or a compound light microscope (20–400×). The degree of the clavateness of bristle tips was determined using the 0–4 rankings described in detail in Hood and Semple (2003). At least five different fruits from each species were observed under the dissecting microscope at a maximum of 70×; in some cases many fruits from many individuals were examined to investigate the frequency of variation. The

majority of observations were made on specimens in the WAT Herbarium; additional specimens on loan from MEXU, MO, OS, SD, TEX-LL and UC (Holmgren et al. 1990) were also examined. In addition to the several methods used in evaluating pappus features listed by Hood and Semple (2003), assessment of the characteristics of the short secondary outer scales or bristles was also systematically undertaken with three traits recorded. The large difference in numbers of pappus bristles per fruit noted in the preliminary survey and the literature led to recording a rough estimate of bristle number for each taxon by counting the number of bristles on three to five representative fruits per taxon. These were compared to counts of numbers of bristles in (Smith 1965; Nesom 1991b; Semple & Bowers 1995; Semple 1996). Thus, Table 1 has eight columns of observational data plus a column for additional comments, while only four were reported by Hood and Semple (2003) and five in Semple and Hood (2005).

Observations on the compound microscope were made from both unmounted fruits and from slides prepared following Semple and Hood (2005). For each species, usually two to three disc floret cypselae with or without corollas were mounted in Cytoseal-60™ mounting medium under a cover slip; immature ray floret fruits were also often mounted on the same slide for comparison. Observations at 20–400× on the compound microscope were made similarly to the observations under the dissecting scope at 30–70×. Observations made on the two kinds of scopes were compared and any discrepancies were resolved by re-examining specimens.

Digital photomicrographs were taken using a Nikon CoolPix 990 camera manually held against the ocular lens of either the dissecting or compound microscope. Pictures were taken of specimens under the compound light microscope with either below stage or above stage lighting. Scanning Electron Microscope (SEM) photomicrographs were made using Kodak FX or Ilford Pan F Plus film commercially developed and subsequently digitized by scanning the negatives. Final digital illustrations were made using CorelDraw 12® from digital images edited with Corel PhotoPaint12® (Corel Corp.). In some illustrations, the contrast was manipulated to increase the difference between pappus bristles and background for illustrative purposes; backgrounds were darkened considerably and sometimes bristles were lightened somewhat to correct for uneven lighting and exposure; the converse was done in bristle tip silhouette illustrations.

RESULTS AND DISCUSSION

The pappus of most species of the Chrysopsidinae consists of 3–4 series (Figs. 1–7) while a minority of taxa has a pappus of 1–2 series (Fig. 8). The quadruple pappus consists of the following series: 1) a well develop secondary outer series usually of many, short, linear-bristly to broad scales; 2) a secondary inner series of mid-length, tapering, non-clavate bristles that were generally 40–80% the length of the primary inner series (Figs. 1F, 1J, 2F, 2N, 4K, 5A, 5M, 6A); 3) a

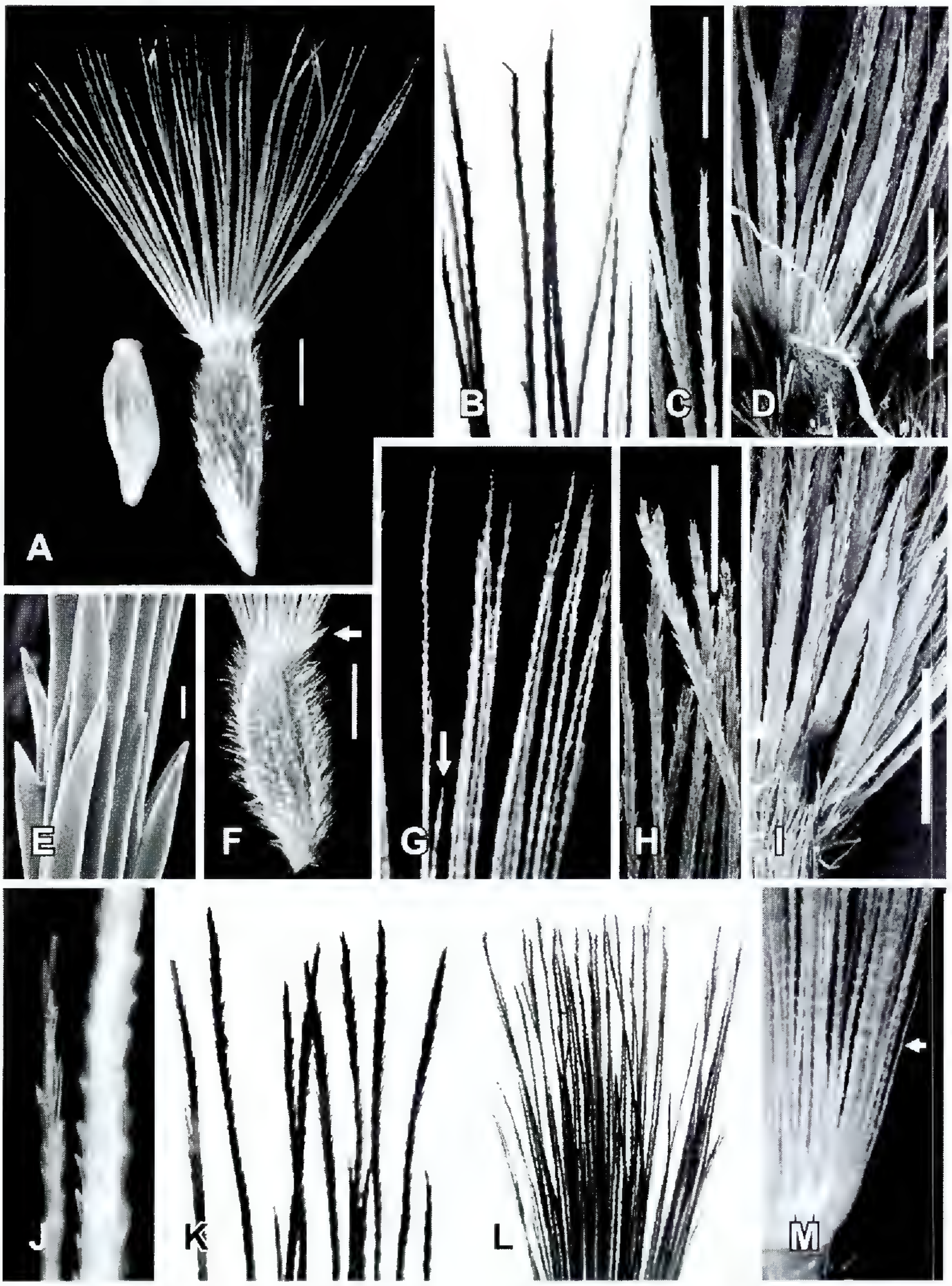


FIG. 1. Fruit and pappus traits of *Heterotheca*, disc fruits except A; scale bars = 1 mm in A and F, = 0.5 mm in C–D and H–I, and = 10 μm in E. **A–B.** *H. grandiflora* (*Semple & Semple 5575* WAT). **A.** Mature epappose ray and pappose disc fruit. **B.** Silhouette of tips of primary inner (long) and outer bristles. **C–E.** *H. inuloides* var. *viridis* (*Canne & Woodland 1928* WAT), SEMs. **C.** Tip of mid length secondary inner bristle. **D.** Secondary outer series scales and overlapping bases of longer bristles. **E.** Detail of barbs on mid portion of inner series bristle. **F–G.** *H. mexicana* (*Teppner s.n.* WAT). **F.** Mature fruit body and secondary outer series bristles (arrow). **G.** Upper portion of secondary inner (arrow) and primary bristles. **H–I.** *H. sessiliflora* subsp. *bolanderioides* (*Semple & Chmielewski 8918a* WAT; SEMs). **H.** Weakly clavate tips of primary inner series bristles. **I.** Secondary outer series scales. **J.** *H. canescens* (*Harms 871* WAT), tip of mid length secondary inner bristle. **K.** *H. camporum* var. *camporum* (*Semple 9902* WAT), clavate tips of primary inner bristles and non-clavate tips of shorter primary outer bristles. **L–M.** *H. oregona* var. *compacta* (*Semple & Heard 5693* WAT). **L.** Silhouette of upper portion of mid length secondary inner bristles and long primary outer and inner bristles. **M.** Linear secondary outer bristle (arrow).

primary outer series of tapering bristles that were 85–95% the length of the primary inner series (Figs. 1B, 1I, 1J, 3D, 4D, 4G, 4K, 5G, 5K, 6KC, 7B, 7E, 7I, 7K, 8A, 8C); and 4) a primary inner series of very subtly to moderately clavate tipped bristles (Figs. 1B, 1I, 4D, 5B, 6D, 7E, 7J). A four-series pappus is plesiomorphic in the North American Clade (sensu Noyes & Rieseburg 1999) of the tribe Astereae (Semple & Hood 2005). *Heterotheca*, *Noticastrum*, and *Pityopsis*, with the plesiomorphic chromosomal base number of $x = 9$, has a quadruple pappus in all or most species, as does the monotypic *Tomentaurum*, whose chromosome number is not yet known but is hypothesized here to be $x = 9$ based on indument and fruit similarities with $x = 9$ *Noticastrum*.

In the genera with lower chromosomal base numbers, *Croptilon* (synonym: *Haplopappus* sect. *Isopappus*: Hall 1928), *Chrysopsis*, and *Bradburia*, the pappus is usually reduced to three pappus series or less but sometimes had 1–few bristles of one or both of the missing series. *Osbertia*, which also was included in *Haplopappus* by Hall (1928), has a vestigial secondary series and a possible biseriate primary series. Thus, in all genera of the Chrysopsidinae, some evidence was found for the presence of at least 2–3 pappus series and usually more.

A large range in pappus lengths and numbers of bristles was observed among genera and within some genera of Chrysopsidinae. The smallest fruits with the lowest numbers of bristles were seen in *Bradburia*, *Chrysopsis*, *Croptilon*, and *Osbertia*. These traits vary considerably in *Heterotheca* and *Pityopsis*. The majority of species of *Noticastrum* examined had the longest pappus bristles and the highest number of bristles observed. Pappus and fruit traits are discussed in detail below by genus with higher base number genera presented first. Data for all taxa examined are presented in Table 1.

***Heterotheca* ($x = 9$; all 24 species, all 48 taxa examined).**—Cypselae straw colored to brown, obconic, compressed laterally or not, those of ray florets often 3-angled, 1–4.3 mm long, sparsely to moderately strigose, dimorphic in sect. *Heterotheca* (Fig. 1A), ray florets usually lacking a pappus and glabrous, rarely pappose and intermediate; ribs 5–10, sometimes dark, resin filled; pappi quadruple or sometimes triple through loss of the secondary inner series, series often intergrading; 23–80 mid to long bristles, averaging about 43 per fruit for the genus, barbs usually evenly arranged around the round shaft for most or all the length of the bristle; secondary outer series obvious to inconspicuous, of linear to narrowly triangular or oblong scales (Figs. 1D, I) or linear bristles (Fig. 1M), these usually 5–15(–30)% the length of the longest primary bristles; rarely up to 40% (some specimens of *H. mucronata* var. *harmsiana*), secondary inner bristles many (*H. oregona*, Fig. 1L) to few or absent (e.g., *H. villosa* var. *nana*), 35–85% the length of the longest primary bristles, sometimes grading in length from linear secondary outer bristles into the primary outer bristles (e.g., *H. brandegei*, *H. stenophylla*, *H. thiniicola*); primary inner bristles tapering distally, 85–95% the length of the primary inner bristles, fewer than the primary

TABLE 1. Pappus variation in subtribe Chrysopsidinae; disc floret cypselae (ray fruit for *B. hirtella*). **Clv**, degree of clavateness of primary inner bristles (0 = not clavate to 4 = strongly clavate); **Clv-Tap**, clavate alternating with tapered bristles (primary inner and outer whorls, y = yes, - not obviously so); **Lgth**, primary outer bristles shorter than primary inner bristles; **Ovrlp**, degree of overlapping of bristles at the base (0 = not observed; 1 = slight overlap; 2 = definite overlap); **2nd-O**, evidence for a secondary outer whorl of short scaly-bristles; **2nd-O wid**, width of the secondary outer bristles (0 = linear, 1 = narrowly triangular, 2 = lanceolate); % = length compared to 1° inner bristles; **No. Br** = approximate number of mid to long bristles (2nd inner, 1° outer and inner whorls; small sample size); percents listed are bristle lengths compared to the length of the primary inner series.

Taxon	Clv	Clv-Tap	Lgth	Ovrlp	2nd-O	2nd-O wid	2nd-O %	No. Br	Comments
***Heterotheca* (*x*=9)**									
sect. *Heterotheca* (dimorphic; ray cypselae nearly always lack pappus)									
H. grandiflora	1	y	y	1	y	0–1	5–15%	50–60	2nd inner bristles few, 40–70%
H. inuloides									
var. *inuloides*	1–2	y	y	1	y	1	5–15%	60–65	2nd inner bristles many, 35–65%
var. *roseum*	1	y	y	1	y	0–1	5–10%	60–65	2nd inner bristles few, 50–70%
var. *viridis*	0–1	y	y	1	y	1	5–10%	60–65	2nd inner bristles few, 70–80%
H. leptoglossa	2	y	y	1	y	1	5–15%	35–45	2nd inner bristles few, 70–80% grading into 1° outer bristles
H. subaxillaris									
subsp. *latifolia*	1	y	y	2	y	0–1	5–10%	25–30	2nd outer bristles 5–10%; 2nd inner bristles 0–very few, 60–70%
subsp. *subaxillaris*	1	y	y	1	y	0–1	5–15%	30–45	2nd outer bristles 5–10%; 2nd inner bristles few, 40–70%
sect. *Ammodia* (rayless)									
H. oregona									
var. *compacta*	1	y	y	1	y	0	5–8%	60–75	2nd outer bristles obscure; 2nd inner bristles few, 50%
var. *oregona*	1	y	y	2	y	0	5–10%	75–85	2nd outer bristles obscure; 2nd inner bristles few, 50%

TABLE 1. cont.

Taxon	Clv Tap	Clv-	Lgth	Ovrlp 0	2nd- wid	2nd-0 %	2nd-0 Br	No.	Comments
var. *rudis*	1	y	y	1	y	0	5–10%	50–55	2nd outer bristles few; 2nd inner bristles few, 40–70%
var. *scaberrima*	1	y	y	1	y	0	15–30%	60–70	2nd inner bristles few, 40–70%, grade into 1° outer bristles
sect. *Phyllotheca*									
H. brandegei (rayless)	1	y	y	1	y	0–1	10–15%	35–55	2nd inner 70–80%, grade into 1° outer bristles
H. canescens	1	y	y	1	y	1	5–10%	25–40	2nd inner bristles few, 50–70%
H. camporum									
var. *camporum*	1	y	y	1	y	0–1	10–15%	30–45	2nd inner bristles 0–few, 70%
var. *glandulissimum*	2	y	y	1	y	0–1	5–10%	30–45	2nd inner bristles few, 50–70%
H. fulcrata									
var. *amplifolia*	0–1	y	y	1	y	0–1	10 -15%	35–45	2nd inner bristles few, 55–75%
var. *arizonica*	1	y	y	1	y	0–1	10 20%	35–45	2nd inner bristles very few, 60 65%
var. *fulcrata*	0–1	y	y	1	y	1–1+	10–15%	25–45	2nd inner bristles 0–few, 70–80%
var. *senilis*	1	y	y	2	y	1	5–15%	28–45	2nd inner bristles few, 70–85%, grade into 1° outer bristles
H. gypsophila	1–2	y	y	1	y	0	5–10%	30–40	2nd inner bristles few, 70–85%, grade into 1° outer bristles
H. jonesii	1	y	y	2	y	1	5–15%	25 35	2nd inner bristles 0–few, 70%
H. marginata	0–1	y	y	1	y	0–1	10–15%	40–52	2nd inner bristles very few, 70–80%
H. mexicana	0–1	y	y	1	y	0–1	10–15%	40–60	2nd inner bristles few, 40 60%
H. monarchensis	1	y	y	1	y	1+	10–15%	25–40	2nd inner bristles 0–very few, 70%
H. mucronata									
var. *mucronata*	1	y	y	1	y	0–1	5–10%	35–50	2nd inner bristles few, 80–85%
var. *harmsiana*	1	y	y	1	y	0–1	10–40%	35–40	2nd outer bristles can be long; 2nd inner bristles few, 70–80%

TABLE 1. cont.

Taxon	Clv Tap	Clv-	Lgth	Ovrlp 0	2nd- wid	2nd-0 %	2nd-0 Br	No.	Comments
H. pumila	0	–	y	2	y	0	10–20%	35–45	2nd inner bristles very few, 75–80%
H. rutteri	0	–	y	1	y	0–1	20–25%	35–46	2nd inner bristles very few, 75–80%
H. sessiliflora									
subsp. *bolanderi*	1	y	y	1	y	1	5–15%	50–70	2nd inner bristles few–many, 55–85%
subsp. *echioides*									
var. bolanderioides	2	y	y	1	y	1	x–x%	35–60	2nd inner bristles few, 55–70%
var. *echioides*	1	y	y	1	y	1	5–15%	25–50	2nd inner bristles 0 or few–many, 60–70%, some fruits have significantly few bristles and lack 2nd inner whorl
var. *camphorata*	2	y	y	1	y	1	5–15%	35–45	2nd inner bristles few, 60–70%
subsp. *fastigiata*									
var. *fastigiata*	0–1	y	y	2	y	0	5–30%	50–70	2nd inner bristles many, 45–85%, grade into 2nd outer and 1° outer whorls
var. *sanjacintensis*	1	y	y	2	y	0	5–30%	50–80	2nd inner bristles many, 45–85%, grade into 2nd outer and 1° inner whorls
subsp. *sessiliflora*	1–2	y	y	2	y	1+	5–10%	45–50	2nd inner bristles few, 50–70%
H. shevockii	1	y	y	0	y	0–1+	5–10%	35–45	2nd inner bristles few, 60–65%
H. stenophylla									
var. *angustifolia*	1	y	y	1	y	0–1	5–15%	35–45	2nd inner bristles few, 50–70%, grade into 1° inner bristles
var. *stenophylla*	1	y	y	1	y	0	15–10%	25–42	2nd inner bristles few, 60–70%, grade into 1° inner bristles
H. thiniicola	1	y	y	2	y	0	10–25%	25–35	2nd inner bristles many, 30–60%, grade into 2nd outer and 1° inner

TABLE 1. cont.

Taxon	Clv Tap	Clv-	Lgth	Ovrlp 0	2nd- wid	2nd-0 %	2nd-0 Br	No.	Comments
H. villosa									
var. *ballardii*	1	y	y	1	y	0–1	5–10%	35–45	2nd inner bristles few, 60–70%%
var. *depressa*	1	y	y	1	y	0	10–15%	35–45	2nd inner bristles few, 50–65%
var. *foliosa*	1–2	y	y	0	y	0–1	8–15%	35–45	2nd inner bristles few, 60–65%
var. *minor*	1	y	y	2	y	0–1	5–15%	30–45	2nd inner bristles few, 60–70%
var. *nana*	1–2	y	y	0	y	0–1	10–15%	28–40	2nd inner bristles 0–very few, 65%
var. *pedunculata*	2	y	y	1	y	1	10–25%	25–45	2nd inner bristles 0–very few, 80%
var. *scabra*	1	y	y	0	y	0–1	8–15%	35–45	2nd inner bristles very few, 60–70%, grade into 1° inner bristles
var. *sierrablancensis*	1–2	y	y	1	y	0–1	10–15%	35–45	2nd inner bristles 70–80%, grade into 1° inner bristles
var. *villosa*	1	y	y	0	y	0	5–15	30–50	2nd inner bristles 60–70%, grade into 1° inner bristles
H. viscida	1–2	y	y	0	y	1	5–15%	23–40	2nd inner bristles very few, 50–60%
H. zionensis	1	y	y	1	y	0	10–15%	30–45	2nd inner bristles few, 50%
Noticastrum (*x*=9)									
N. acuminatum	0–1	y	y	2	y	0	5–20%	75–90	2nd inner bristles many, 65–75%
N. calvatum	0–1	y	y	2	y	0	5–10%	90–100	2nd inner bristles few, 80%
N. diffusum	0–1	y	y	2	y	0	10–30%	75–80	barbs of bristles tinted red; 2nd inner bristles few, 60–80%
N. gnaphaloides	0–1	y	y	2	y	0	5–10%	100–115	2nd inner bristles few, 80%
N. hatsbachii	0–1	y	y	2	y	0	10–20%	45–50	2nd inner bristles few, 40–80%
N. macrocephalum	0–1	y	y	2	y	0	10–30%	80–90	2nd inner bristles few, 80–85%
N. marginatum	1	y	y	2	y	0	5–15%	75–80	2nd inner bristles few, 70–85%
N. sericeum	0–1	y	y	2	y	0	10–20%	120–125	2nd inner bristles few, 70–80%

TABLE 1. cont.

Taxon	Clv Tap	Clv-	Lgth	Ovrlp 0	2nd- wid	2nd-0 %	2nd-0 Br	No.	Comments
***Tomentaurum* (unknown)**									
T. nivea	0–1	y	y	2	y	0	10–20%	75–85	2nd inner bristles few to many, 60–70%
Pityopsis (*x*=9)									
sect. *Pityopsis*									
P. falcata	0–1	y	y	1	y	0	10–15%	30–40	2nd inner bristles 0–few, 45–80%
P. flexuosa	1	y	y	1	y	0	5–10%	30–50	2nd inner bristles 0–few, 45–85%
P. pinifolia	1	y	y	2	y	1	10–15%	25–30	2nd inner bristles not seen
P. ruthii	0–1	y	y	1	y	1	5–15%	25–35	2nd inner bristles, few, 40–85%
sect. *Graminifoliae*									
P. aspera									
var. *adenolepis*	0–1	y	y	2	y	0–1	10–20%	25–35	2nd inner bristles 0–few, 70 -80%
var. *aspera*	0–1	y	y	1	y	0–1	5–15%	30–35	2nd inner bristles few, 70–80%
P. graminifolia									
var. *aequilifolia*	0	y	y	0	y	0–1	10–15%	40–45	2nd inner bristles 0–few, 70–80%
var. *graminifolia*	1	y	y	2	y	0	10–20%	32–40	2nd inner bristles few, 75–85%
var. *latifolia*	0	y	y	1	y	0	5–15%	35–45	2nd inner bristles 0–few, 60–85%
var. *tenuifolia*	0	y	y	1	y	0–1	5–15%	35–45	2nd inner bristles 0–very few, 70–85%, grading into 1° outer bristles
var. *tracyi*	0–1	y	y	0	y	0–1	5–10%	35–45	2nd inner bristles few, 50–85%
P. oligantha	0–1	–	y	1	y	0–1	5–10%	25–40	2nd inner bristles 0–very few, 75 85%
***Croptilon* (*x*=7,6,5,4)**									
C. hookerianum									
var. *graniticum* (*x*=7)	0	–	y	0	y	0	5–20%	30–35	2nd whorls absent or very rarely a short linear bristle present

TABLE 1. cont.

Taxon	Clv Tap	Clv-	Lgth	Ovrlp 0	2nd- wid	2nd-0 %	2nd-0 Br	No.	Comments
var. *hookeri* (*x*=6)	0	–	y	0	y	0	5–10%	25–30	2nd outer bristles 0–few; 2nd inner bristles 0–few, 50–70%
var. *validum* (*x*=5)	0	–	y	0	y	0	(5–10%)	25–30	2nd outer bristles 0–very rarely vestigial (or abnormal short 1° bristle)
C. rigidifolium (*x*=6, 5)	0	–	y	0	n	0	5–10%	25–30	2nd out bristles 0–few; 2nd outer bristles few 35–75%, grade into 1° bristles
C. divaricatum (*x*=4)	0	–	y	1	n	–	–	25–30	2nd outer bristles not seen; 1° outer bristles 70–80%, sometimes grade into 1° inner
***Bradburia* (*x*=4,3)**									
B. hirtella	0–1(–2)	y	y	2	y	2	10–15%	30–36	ray florets—2nd inner bristles few, 50–60%; 1° outer 70–95%, grade into 1° inner; see text for comments on pigmentation: disc florets—reduced pappus, 0–5 short scales to long broad–based bristles
B. pilosa	0(–1)	y	y	0	y	2	8–20%	18 25	2nd outer whorl of large, obvious to naked eye, lanceolate–oblong scales 0.1–0.2 mm wide; 2nd inner bristles 0–few, 75–85%, usually absent, grade into 1° bristles; 1° outer bristles few, grade into 1° inner bristles; see text for comments on pigmentation.

TABLE 1. cont.

Taxon	Clv	Clv-	Lgth	Ovrlp	2nd-	2nd-O	2nd-O	No.	Comments
	Tap			O	wid	%	Br		
Chrysopsis (x=5, 4 and x_2 = 9; most species lack 2nd inner bristles and have few primary outer bristles)									
C. delaneyi	2	y	y	0	y	0	15–25%	30–40	2nd inner bristles not seen
C. floridana	1	y	y	1	y	0	10–15%	25–30	2nd inner bristles not seen
C. godfreyi									
var. *godfreyi*	2	y	y	0	y	0	10%	30–35	2nd inner bristles not seen
var. *viridis*	1	y	y	–	y	0	5–10%	30–35	2nd inner bristles not seen
C. gossypina (x_2 = 9)									
subsp. *cruiseana*	1	y	y	0	y	0 1	10 15%	30 35	2nd inner bristles not seen
subsp. *gossypina*	1	y	y	0	y	0 1	10 15%	25 35	2nd inner bristles not seen
subsp. *hyssopifolia*	1	y	y	0	y	0 1	10 15%	25 30	2nd inner bristles not seen
C. highlandsensis	2 3	y	y	1	y	0	10 25%	30–35	2nd inner bristles very few, 55 60%
C. lanuginosa	2	y	y	0	y	1	10–15%	25–30	2nd inner bristles not seen
C. latisquamea	1	y	y	1	y	0	10–15%	30–35	2nd inner bristles not seen
C. linearifolia									
subsp. *dressii*	2	y	y	–	y	1	5–15%	20–35	2nd inner bristles not seen
subsp. *linearifolia*	2	y	y	–	y	0–1	10–15%	25–30	2nd inner bristles not seen
C. mariana (*x* = 4)	1–2	y	y	1	y	0–1	5–15%	25–30	2nd outer bristles no wider than in some other species of genus (sample includes 2*x*, 4*x*, 6*x*, 8*x*); 2nd outer bristles absent; 1° outer bristles 0–few
C. scabrella	2	y	y	1	y	0	15–30%	25–35	2nd inner bristles not seen
C. subulata	2	y	y	2	y	0–1	8–15%	20–25	2nd inner bristles not seen
***Osbertia* (x=5)**									
O. bartlettii	0	–	y	0	n	–	–	20–25	1° vary in length (80–100%); one fruit had 1 fine 2nd bristle 25% the

Table 1. cont.

Taxon	Clv Tap	Clv-	Lgth	Ovrlp 0	2nd- wid	2nd-0 %	2nd-0 Br	No.	Comments
O. chihuahuana	1–2	y	y	0–1	y	0	5–12%	25–30	length of the longest 1° bristles 2nd outer bristles few; 2nd inner bristles 45–65% of the length of the longest 1° bristles; 1° outer bristles 85–95%, grade into 1° inner bristles
O. stolonifera	0–1	–	y	1	y	0	5–40%	25–30	2nd outer bristles grade into 2nd inner bristles; 2nd inner bristles 50–70% of the length of the longest 1° bristles; 1° outer bristles 90–95%, grade into weakly clavate 1° inner bristles

inner bristles; primary inner bristles very weakly (Fig. 1B) to moderately clavate (Fig. 1K), 3.4–10 mm long.

***Noticastrum* (x = 9; eight of 19 species examined).**—Cypselae straw colored to brown, fusiform, 4–6 mm long, sparsely to moderately strigose, sometimes stipitate glandular distally (Fig. 2B–C) or over entire surface (Fig. 2H); ribs, 16–22, surface between ribs usually golden-brown, translucent, resin filled; pappi quadruple, each series usually grading into next, 45–125 mid to long bristles, averaging about 87 per fruit for the genus, straw colored, orange-rust or purplish (e.g., *N. diffusum*; Fig. 2A), yellow-rust pigment in shaft over entire length, the red pigment concentrated in the barb tips (Fig. 2F), barbs evenly arranged around the round shaft along the entire length of the bristles; secondary outer series obvious to inconspicuous, linear triangular scales (Figs. 2N) to linear bristles (Fig. 2B), usually 5–20(–30)% the length of the longest primary bristles; secondary inner bristles many, 40–85% the length of the longest primary bristles (Fig. 2E); primary inner bristles many, 85–95% the length of the primary inner bristles; primary inner bristles very weakly (Fig. 2D) to sometimes moderately clavate, 7–14 mm long, much exceeding the disc corolla lobes.

***Tomentaurum* (x = unknown; monotypic, *T. nivea* examined).**—Cypselae fusiform, 4–5 mm long, densely strigose (Figs. 3B–C); ribs 10–18, shallow, obscured by hairs; pappi quadruple, each series usually grading into next, 75–85 mid to long bristles, averaging about 80 per fruit, straw colored, barbs evenly arranged around the round shaft along the entire length of the bristles; secondary outer series obvious to inconspicuous, very linear triangular scales to tapering bristles (Figs. 3H–I), 10–20% the length of the primary inner bristles; secondary inner bristles few to many, 40–85% the length of the longest primary bristles (Fig. 3G); primary inner bristles many, 85–95% the length of the primary inner bristles (Fig. 3D); primary inner bristles very weakly to weakly clavate (Fig. 3E–F), 10–11 mm long.

***Pityopsis* (x = 9; all seven species, all 11 taxa examined).**—Cypselae straw colored to often dark reddish-brown, narrowly to broadly fusiform, 3–4 mm long, ribs 8–10, sparsely to moderately densely strigose; pappi quadruple or sometimes triple through loss of the secondary inner series, 25–46 mid to long bristles, averaging about 37 per fruit for the genus, light tan to straw colored, sometime pale rust colored proximally, barbs evenly arranged around the round shaft along the entire length of the bristles; secondary outer series of linear (Figs. 4E, G arrows) to broad (Figs. 4K–L), barbed scales, 5–15(–20)% the length of the primary inner bristles; secondary inner series of tapering bristles, few, 45–85% the length of primary inner bristles; primary outer series of tapering bristles 90–95% of primary inner bristles (Figs. 4C–D, F, H; arrows); primary inner series of weakly clavate bristles (Fig. 4D), 4–9 mm long.

***Croptilon* (x = 7, 6, 5, 4; all three species, all five taxa examined).**—Cypselae straw colored to brown or reddish-brown, sometimes mottled, fusiform to nar-

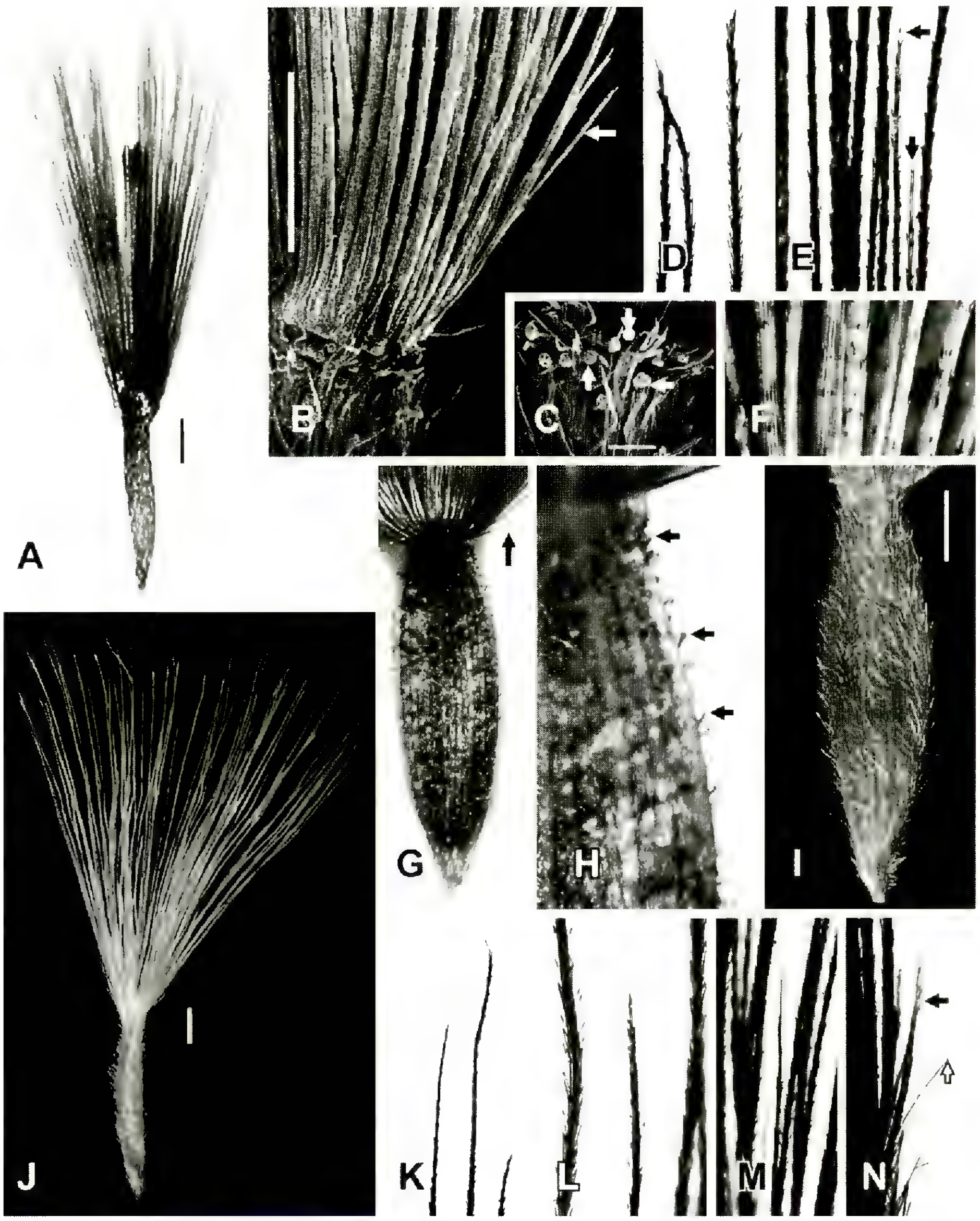


FIG. 2. Fruit and pappus traits of *Noticastrum*, disc fruits; scale bars = 1 mm (unless otherwise noted). **A–F.** *N. diffusum* (*Zardini 1094* TEX). **A.** Fruit with rusty reddish anthocyanotic quadruple pappus. **B.** SEM of mature fruit showing linear secondary outer bristles (arrow) and the bases longer series bristles; scale bar = 0.5 mm. **C.** SEM of stipitate glands (arrows) on upper fruit body; scale bar = 100 μm. **D.** Tips of primary inner series bristles. **E.** Tips of secondary inner series bristles (arrows) among much longer primary series bristles. **F.** Base of pappus bristles with anthocyanotic barbs. **G–H.** *N. calvatum* (*Hatschbach 52819* MO). **H.** Fruit body and secondary outer pappus bristle (arrow). **I.** Detail of multi-ribbed fruit body with stipitate glands (arrows). **I–J.** *N. macrocephalum* (*Montes 14942* MO). **I.** Mature fruit body. **J.** Immature fruit with four series of bristles. K. Tips of non-clavate to very weakly clavate primary bristles. **L.** Tip of primary outer bristle and near-tip portion of a longer primary bristle. **M.** Tip of secondary inner bristle and upper mid portions of much longer primary series bristles. **N.** Short secondary outer pappus bristle (solid arrow) and long hair of fruit body (open arrow).

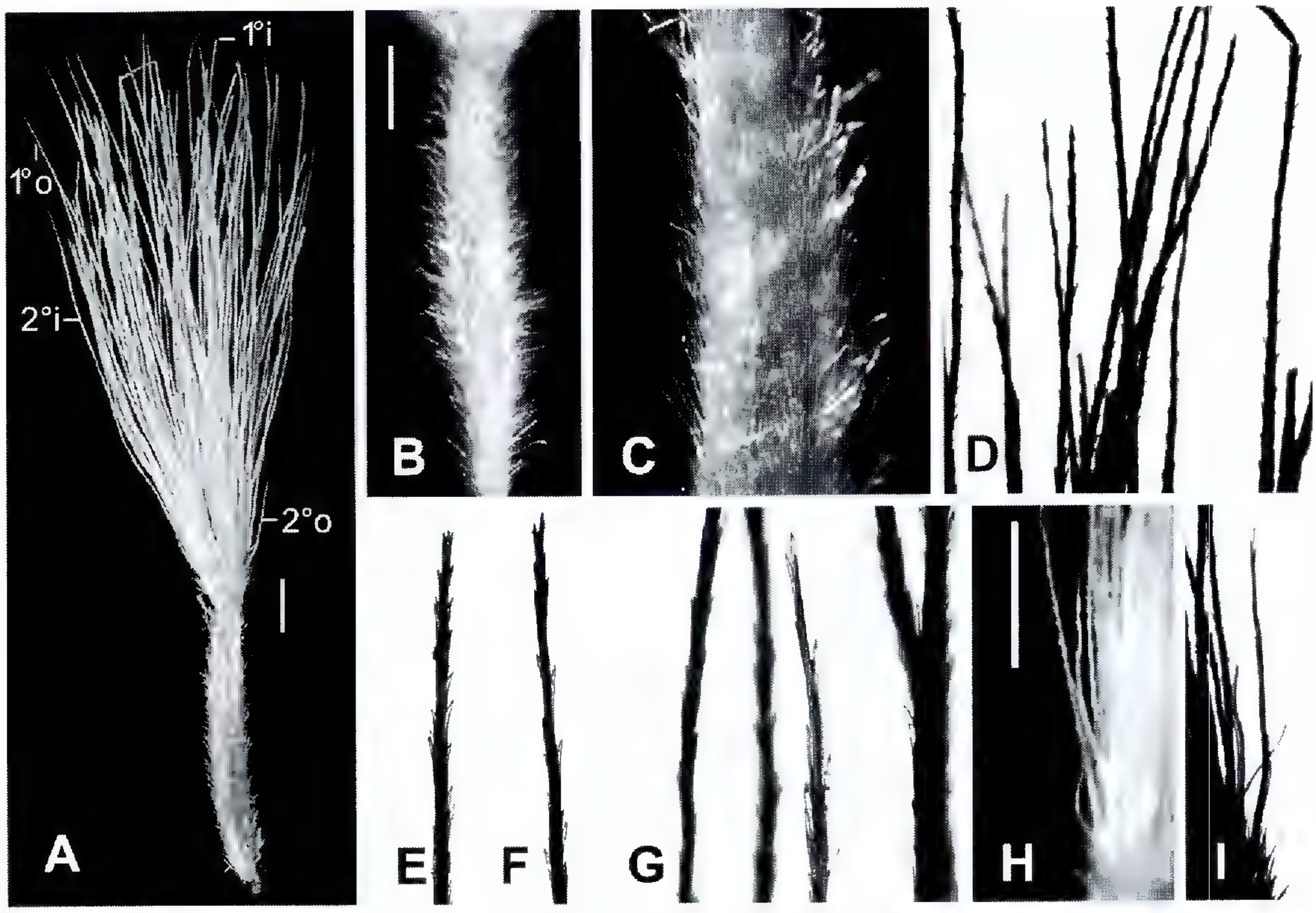


FIG. 3. Fruit and pappus traits of *Tomentaurum nivea*, disc fruits (*Pringle 1645* MO); scale bars = 1 mm in A–B, = 0.5 mm in H. **A.** Nearly mature fruit with secondary outer series (1°o), secondary inner series (2°i), primary outer series (1°o) and primary inner series (1°i) bristles indicated. **B.** Fruit body. **C.** Mid portion of fruit body. **D.** Tips of long primary bristles, a few are broken off. **E–F.** Tips of primary inner bristles. **G.** Tip of secondary inner bristle (center) and mid portions of four primary bristles. **H–I.** Secondary outer series bristles.

rowly obconic, 2–3.2 mm long, ribs 10–20, sometimes either the ribs or faces between them golden-brown to brown translucent, resin filled, sparsely to moderately densely strigose (Figs. 4A, G, K); pappi quadruple, triple, double, or sometimes single, 25–35 mid to long bristles, averaging about 28 per fruit for the genus, somewhat to dark rust colored in shaft, darkest proximally, becoming paler to whitish distally, barbs not pigmented, barbs evenly arranged around the round shaft along the entire length of the bristles; secondary outer series of linear bristle-like scales, 0–few (Figs. 5D–E, I–J, N–O), 5–10(–20)% the length of the primary inner bristles (Figs. 5D–F, I–J, O); secondary inner series of tapering bristles, absent or rarely 1–2, 50–70% the length of primary inner bristles (Fig. 5A, M; arrow) or these just atypically short primary outer series bristles; primary outer series of tapering bristles 80–95% of primary inner bristles, grading into primary inner bristles (Figs. 5A, 5G, 5K–L); primary inner whorl of non-clavate/very weakly clavate (Fig. 5B) to weakly clavate bristles (Fig. 5L), 4–9 mm long.

Croptilon has been treated as *Haplopappus* sect. *Isopappus* (Hall 1928; Smith 1965) and described as having a pappus with "a single series of equal (or nearly

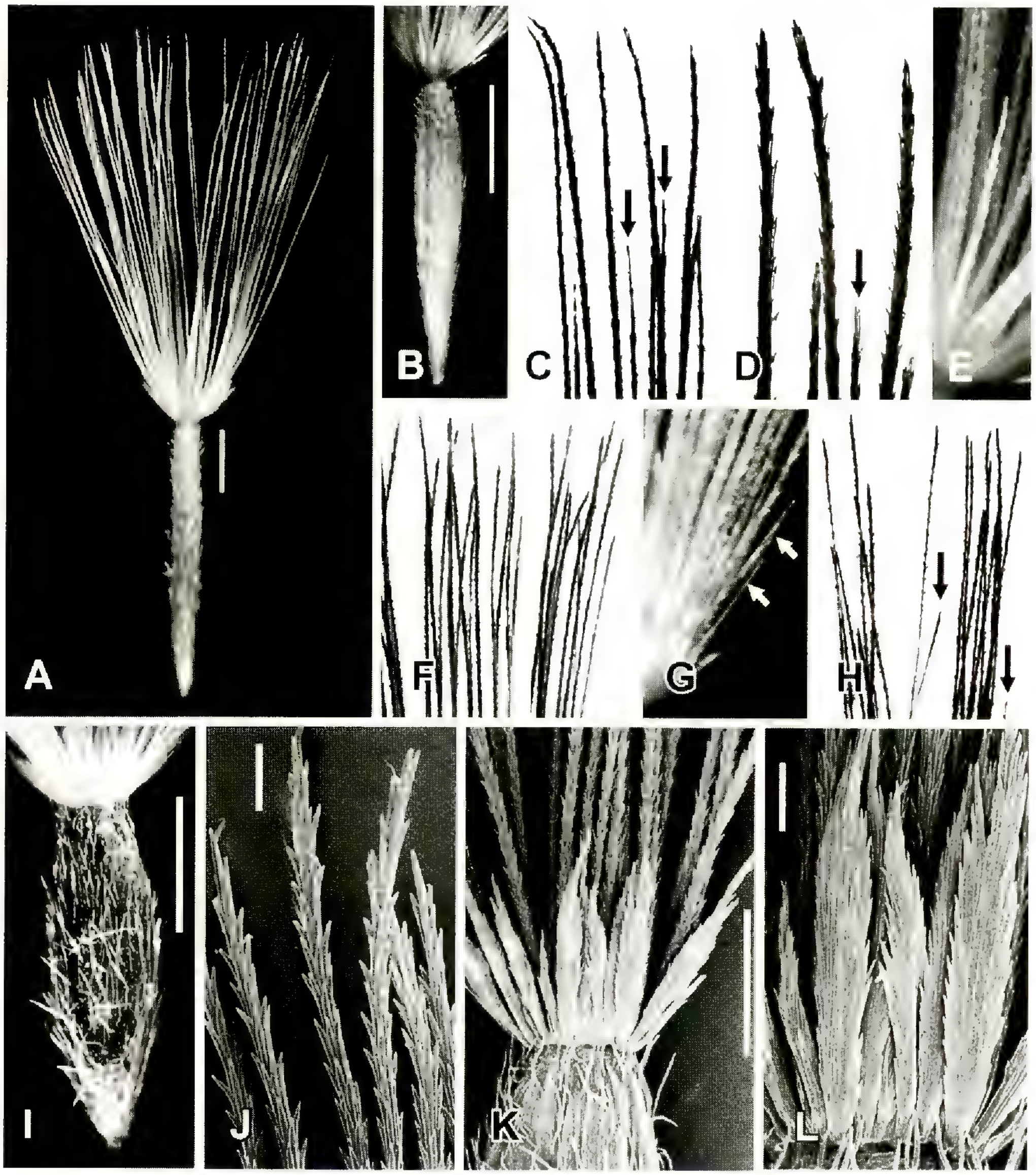


Fig. 4. Fruit and pappus traits of *Pityopsis*, disc fruits; scale bars = 1 mm in A–B and I, = 100 μm in J, = 0.5 mm in K, and = 0.1 mm in L. **A.** *P. graminifolia* var. *aequilifolia*, mature fruit (*Semple et al. 3992* WAT). **B–E.** *P. falcata* (*Semple 3366* WAT). **B.** Fruit body. **C–D.** Tips of weakly clavate primary inner bristles and attenuate, shorter primary outer bristles (arrows). **E.** Bristly secondary outer series linear scale. **F–G.** *P. flexuosa* (*Godfrey 75754* WAT). **F.** Tips of primary inner and outer bristles. **G.** Bristly secondary outer series scales (arrows) **H.** *P. pinifolia* (*Semple 10537* WAT, tips of primary inner and outer (arrows) series bristles. **I–L.** *P. aspera* var. *adenolepis* (*Semple et al. 4041* WAT). **I.** Mature fruit body. **J–L.** SEMs. **J.** Clavate tips of primary inner series bristles. **K–L.** Secondary outer series scales (differentially highlighted to clarify in K) and proximal portions primary series bristles.

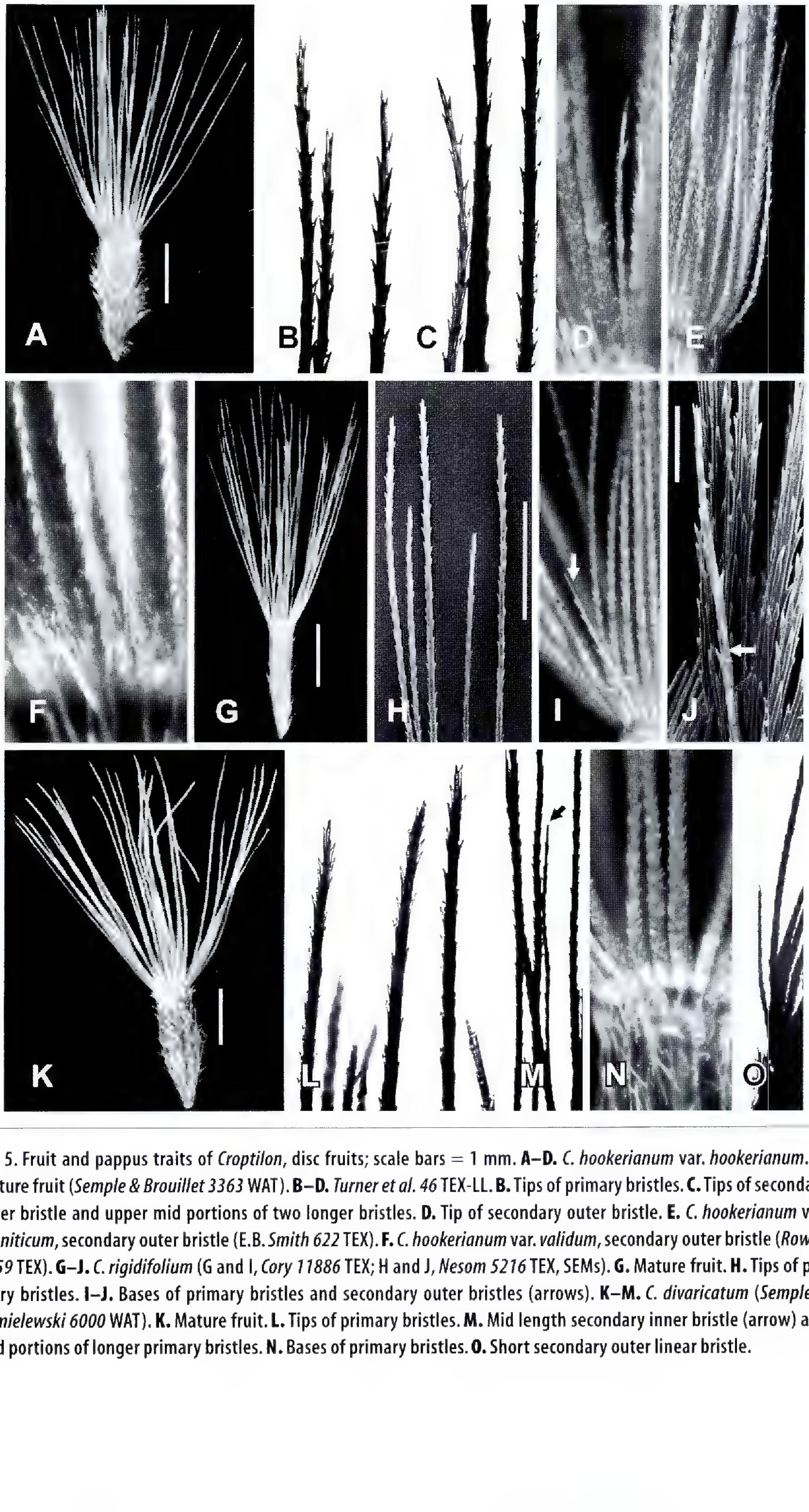


FIG. 5. Fruit and pappus traits of *Croptilon*, disc fruits; scale bars = 1 mm. **A–D.** *C. hookerianum* var. *hookerianum*. **A.** Mature fruit (*Semple & Brouillet 3363* WAT). **B–D.** *Turner et al. 46* TEX-LL. **B.** Tips of primary bristles. **C.** Tips of secondary inner bristle and upper mid portions of two longer bristles. **D.** Tip of secondary outer bristle. **E.** *C. hookerianum* var. *graniticum*, secondary outer bristle (E.B. *Smith 622* TEX). **F.** *C. hookerianum* var. *validum*, secondary outer bristle (*Rowell 4259* TEX). **G–J.** *C. rigidifolium* (G and I, *Cory 11886* TEX; H and J, *Nesom 5216* TEX, SEMs). **G.** Mature fruit. **H.** Tips of primary bristles. **I–J.** Bases of primary bristles and secondary outer bristles (arrows). **K–M.** *C. divaricatum* (*Semple & Chmielewski 6000* WAT). **K.** Mature fruit. **L.** Tips of primary bristles. **M.** Mid length secondary inner bristle (arrow) and mid portions of longer primary bristles. **N.** Bases of primary bristles. **O.** Short secondary outer linear bristle.

equal) capillary bristles, more or less ferruginous" (Smith 1965). Nesom (2000) as noted in the introduction also described the pappus as being in a single series. The results presented here indicate that the pappus neither consists of a single series nor are the bristles equal or nearly equal. The higher base number taxa (e.g., *C. hookerianum* var. *graniticum* with x=7) are more likely to have three or four series of bristles, while the lowest base number taxon, *C. divaricatum* with x = 4, may have only 1–2 series. The gradation in lengths of longer bristles and the lack of clearly clavate bristle tips results in uncertainty in determining the number of series present. The conclusion that multiple series are present is based on observations of many fruits, some of which have longer bristles of 2–3 distinct lengths. The much shorter outer bristles clearly exterior to the long bristles are essentially the same as the secondary outer series scales/bristles of some species of genera long recognized to have a short outer series, e.g. *Heterotheca*, *Noticastrum*, *Pityopsis* and *Chrysopsis*. The small fruit size generally correlates with a lower number of bristles and very few bristles in some series.

***Bradburia* (x = 4, 3; two species with very different pappi traits).**—1) *B. hirtella*: ray florets fertile, disc florets functionally staminate, ovary aborts; ray floret cypselae straw colored to brown or reddish-brown, obconic, ± triangular in cross-section, ca. 2 mm long, 5–10 shallow ribs per face, moderately strigose, more densely so along angles (Fig. 6A); pappi quadruple or triple, the series grading into each other, 18–26 mid to long, long-barbellate bristles (Fig. 6A), densely pigmented red proximally to only the barbs pigmented one third to one half the length, pale yellow to pale rust grading to white distally; secondary outer bristles linear, 5–20% the length of the longest inner bristles (Fig. 6B), barbs evenly arranged around the round shaft along the entire length of the bristles, uneven on the distal portion of the longer bristles; secondary inner bristles grading from secondary outer into primary outer, tapering, 25–85% the length of primary inner bristles; primary inner bristles round proximally, flattened distally and weakly to moderately clavate (Fig. 6C), 2.5–3.5 mm; mid to longer bristles pigmented proximally, the red pigment concentrated in the barbs (Figs. 6B, D). Disc floret pappi reduced to 0–5 scales and/or broad-based proximally flattened bristles (Figs. 6G–J), the longest weakly clavate (Fig. 6H). — 2) *B. pilosa*: ray and disc pappi similar, cypselae obconic, slightly compressed, sparsely strigose, 10–20 shallow ribs; pappi triple or double (Fig. 7K); secondary outer scales linear to lanceolate or oblong (Fig. 6L), 0.05–0.2 mm wide, barbellate proximally, margins jagged, especially distally; secondary outer bristles absent; primary outer bristles tapering, 0–2, 75–85% the length of the inner bristles; primary inner bristles tapering or only very remotely clavate; all longer bristles pigmented proximally with the concentration decreasing distally, yellow to rust, pigment in shaft, not barbs.

The combination of broad, whitish, light-reflecting scales and proximally

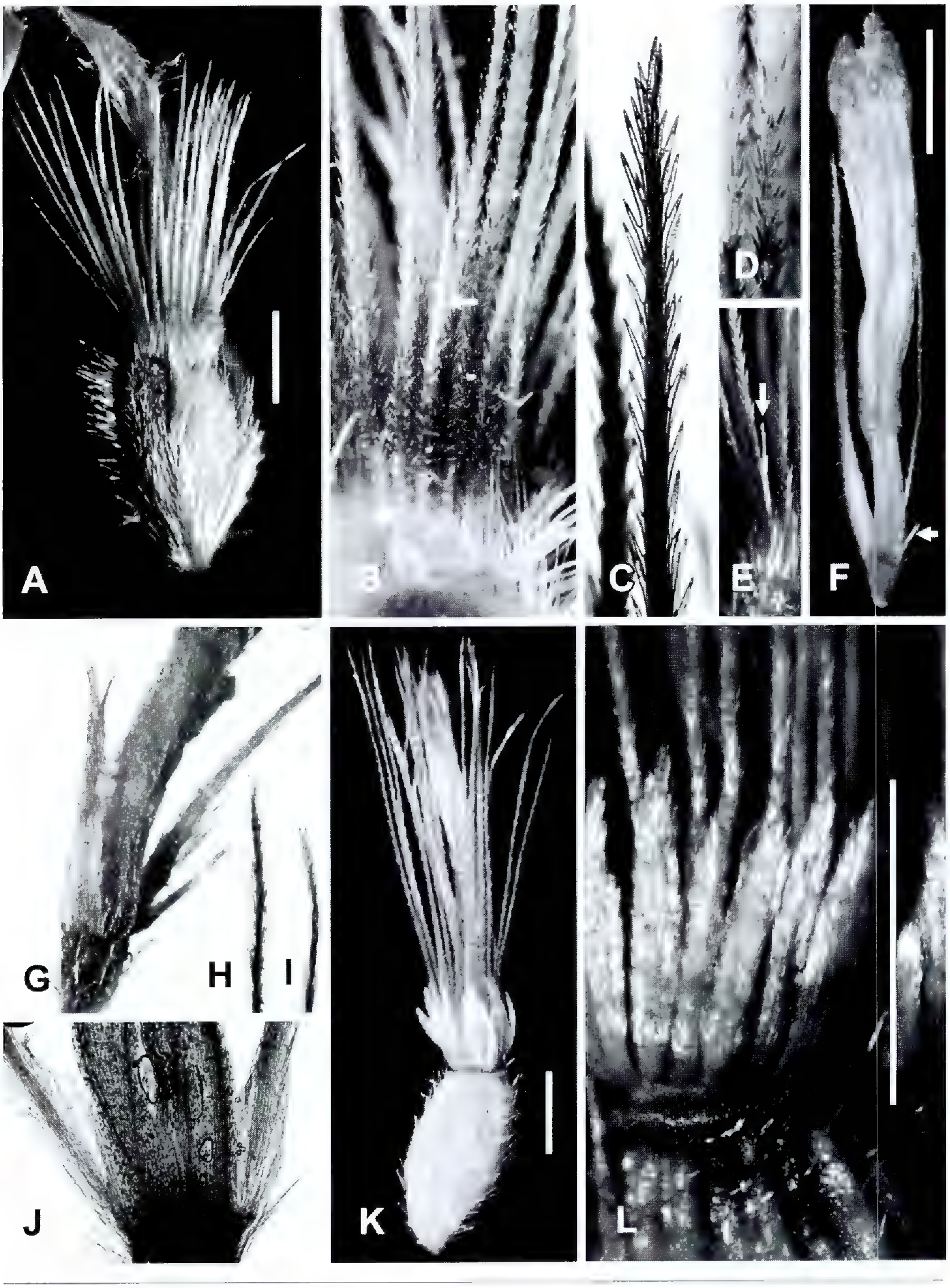


FIG. 6. Fruit and pappus traits of *Bradburia*; scale bars = 1 mm. A–J. *B. hirtella* (*Nesom 7470* WAT). **A–E.** Ray fruit. **B.** Pigmented terete bases of long bristles and long secondary outer bristle (arrow). **C.** Tip of distally flattened long primary inner bristle. **D.** Mid portion of bristles with distal barbs less pigmented then proximal barbs. **E.** Very small secondary outer bristle. **F–J.** Functionally staminate disc floret. **F.** Floret with one secondary outer scale (arrow) and two long broad-based bristles. **G.** Base of floret with broad scales. **H.** Tip of longer scale on right in G. **I.** Tips of shorter scale on left in G. **J.** Details of scales bases. **K–L.** *B. pilosa*, disc fruit (*Semple & Brammall 2753* WAT). **K.** Mature fruit. **L.** Secondary outer series scales.

darker-pigmented, long bristles as background makes the secondary outer series of *Bradburia pilosa* obvious to the naked eye. The narrower to mid-width scales are similar to broader scales in some species of *Chrysopsis* and *Heterotheca*. The widths of the secondary outer scales/bristles in *Heterotheca* and *Chrysopsis* form a continuum that overlaps at the wide end with the narrower width scales of *B. pilosa*. The broader scales of *B. pilosa* are unique in the subtribe. The broad scaly bases of the few, long bristles attached to the aborted ovary of the disc florets of *B. hirtella* are also unique in the subtribe. Possibly, the genes controlling normal scale and bristle development have been expressed together in single structures rather than separately in different series of structures in disc floret pappus development. Therefore, but in different ways, the two species of *Bradburia* have broader pappi members than found in all other genera in the subtribe.

The phylogenetic position of *Bradburia* is uncertain. Nesom (1991a, d) included the two species of *Bradburia* in *Chrysopsis* sect. *Bradburia*. Semple (1996) transferred *C. pilosa* to *Bradburia* as defined here. In the cladistic study by Semple and Tebby (1999), *Bradburia* grouped with *Croptilon* and *Heterotheca*, while *Chrysopsis* grouped with *Pityopsis*, *Noticastrum*, and *Tomentaurum*. Based on pappus traits, *Bradburia* is no more similar to *Croptilon* than to *Chrysopsis*. Pigmentation of bristles is similar in *Bradburia* and *Croptilon*, but a well developed secondary outer series is shared by *Bradburia* and *Chrysopsis*, although the scales are much broader on average in *B. pilosa* than in any species of *Chrysopsis*. A DNA sequence based phylogeny of the subtribe has not been published. Until such a study is completed, the phylogenetic position of *Bradburia* within the subtribe remains uncertain, although it is likely derived from either the *Croptilon* or *Chrysopsis* lineages, unless a separate dysploid series from $x = 9$ is hypothesized.

***Chrysopsis* (*x* = 5, 4, *x*2 = 9; all taxa examined, 11 species, 15 taxa).**—Cypselae straw colored or rarely dark red-purple, compressed obconic, smooth (Fig. 7G) or with 1–10 shallow ribs and sometimes 1–5, yellow to red brown, clavate, translucent ridges per side (Fig. 7D), sparsely to densely strigose, 1.5–3 mm; pappi triple or rarely quadruple, sometimes double in *C. mariana*, barbs evenly arranged around the round shaft along the entire length of the bristles; secondary outer series of linear (Fig. 7F) to narrowly triangular, jagged-edged scales (Figs. 7C, 7L), 0.4–1.4 mm, 5–15(25)% the length of the primary inner bristles, 20–40 mid to long barbellate bristles in 1–2(–3) series, whitish to straw colored; secondary inner series usually absent, rarely 1–3 tapering bristles 45–85% the length of primary inner bristles; primary outer series of tapering bristles 85–95% of primary inner bristles (Figs. 7B, E, I arrow, K); primary inner series of weakly to moderately clavate bristles (Figs. 7E, I–J), 4–7 mm long.

Some fruits of *C. mariana* ($x = 4$) have a true double pappus of just short secondary outer series scales and long, clavate primary inner series bristles (Fig.

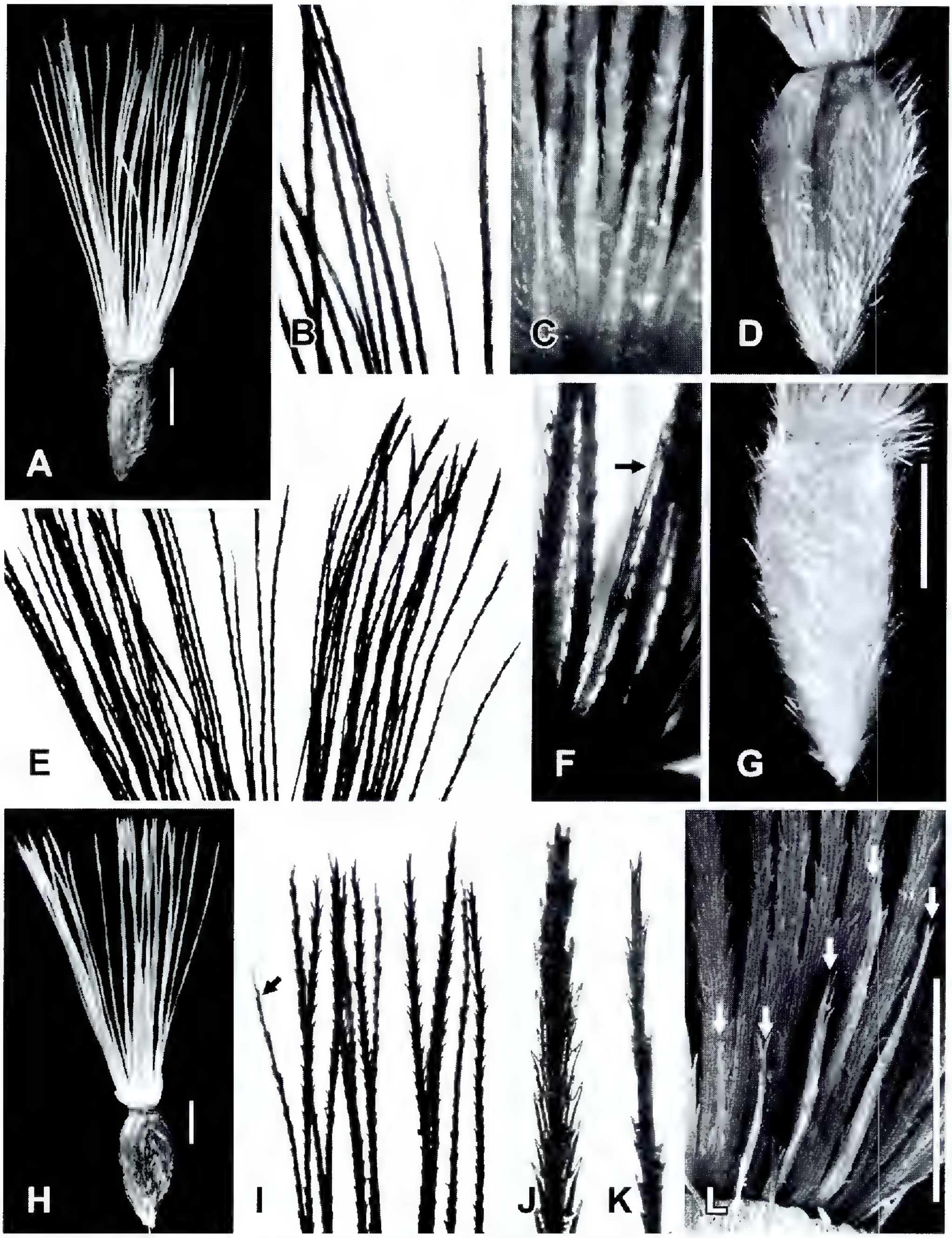


FIG. 7. Fruits and pappus traits of *Chrysopsis*, disc fruits; scale bars = 1 mm in A, G, and H; = 0.5 mm in L. **A–C.** *C. latisquamea* (*Semple et al. 2753* WAT). **A.** Mature fruit. **B.** Tips of primary bristles. **C.** Secondary outer bristle-like scales. **D.** Fruit body with enlarged translucent reddish-brown resin-filled rib, *C. gossypina* (*Semple et al. 3126* WAT). **E.** Distal portion of pappus, *C. delaneyi* (*Semple & Semple 7476* WAT). **F.** Linear secondary outer bristle-like scale (arrow); *C. linearifolia* (*Godfrey 75759* WAT). **G.** Mature fruit body, *Chrysopsis godfreyi* (*Semple & Godfrey 3149* WAT). **H–L.** *C. mariana* (*Semple & Chmielewski 6214* WAT). **H.** Mature purplish-red fruit with long primary inner series and short secondary outer series; 0–2 primary outer bristles on other fruits examined. **I.** Tips of primary inner bristles and one primary outer bristle (arrow). **J.** Linear to narrowly triangular secondary outer scales (arrows).

7H, 7L); others fruits produced by the same individual have a few tapering primary outer bristles (Fig. 7I). This is true for fruits at all four ploidy levels (2n=8, 16, 24, 32; Semple & Chinnappa 1986). In his cladistic study, Nesom (1991a) scored the secondary outer scales of both *Bradburia pilosa* and *C. mariana* as "(1) scales", but the latter has scales that are very narrowly triangular to only narrowly triangular on the same fruit like some other species of *Chrysopsis*, not like those of *B. pilosa*.

Osbertia (*x* = 5; three of three species examined) — Cypselae straw-colored to brown, cylindrical-fusiform, 1.0–1.5 mm long, sparsely strigose, ribs 8–16, superficial (Figs. 8N, T), sometimes either the ribs or faces between them golden-brown to brown translucent; pappi quadruple, triple, double (Fig. 8M) or single and rarely vestigially triple, the series distinct or grading into each other (Fig. 8A); 20–35 bristles, barbs evenly arranged around the round shaft along the entire length of the bristles, barbs sometimes small and less obvious; secondary outer bristles linear, 3–10, sometimes grading into secondary inner bristles, absent in *O. bartlettii* or very rarely one linear, fine, short bristle (Figs. 8R–S), 5–40% the length of the inner long bristles; secondary inner bristles tapering, fine, linear, 5–10, 45–70% the length of primary inner bristles, absent in *O. bartlettii*; primary outer bristles fewer than and often grading into the primary inner bristles, 85–95% the length of the primary inner; primary inner bristles weakly to sometimes moderately clavate tapering (Figs. 8C, I–J), or in *O. bartletii* tapering and subequal or the shortest 80% if all long bristles are included in a single series, 2.5–7.5 mm long.

The pappus of *Osbertia* differs in the three species, but in general all have rather linear and short-barbed bristles. The four series are most distinct lengthwise in *O. chihuahuana* (Figs. H–L) and least distinct or reduced to two or one series in *O. bartlettii*. In the type species *C. stolonifera*, the secondary outer and inner series grade together, as do the primary outer and inner series, but the secondary and primary series are clearly of different lengths (Figs. A–B). The two secondary outer series could be interpreted as a single series highly variable in length, and the primary outer and inner could be interpreted as a single series grading from non-clavate shorter bristles to weakly clavate longer bristles. Overall there is a spiral arrangement from very short, fine, outer bristles to long coarser inner bristles, with the outer members of the series clearly placed externally to and overlapping the longer inner members of the series.

Previous authors have considered the pappus of *Osbertia* to be simpler than described above. Turner and Sundberg (1986) described the pappus of *Osbertia* as having "numerous setae in a single series" 4–6 mm long. Nesom (2000) noted that *O. chihuahuana* Turner & Sundberg had "a short, outer series commonly present" (i.e., a double pappus) but did not describe the individual bristles or scales. Nesom (1991c) stated that pappus of *O. bartlettii* was "uniseriate, of 15–20 barbellate bristles without an outer series." The single short outer bristle

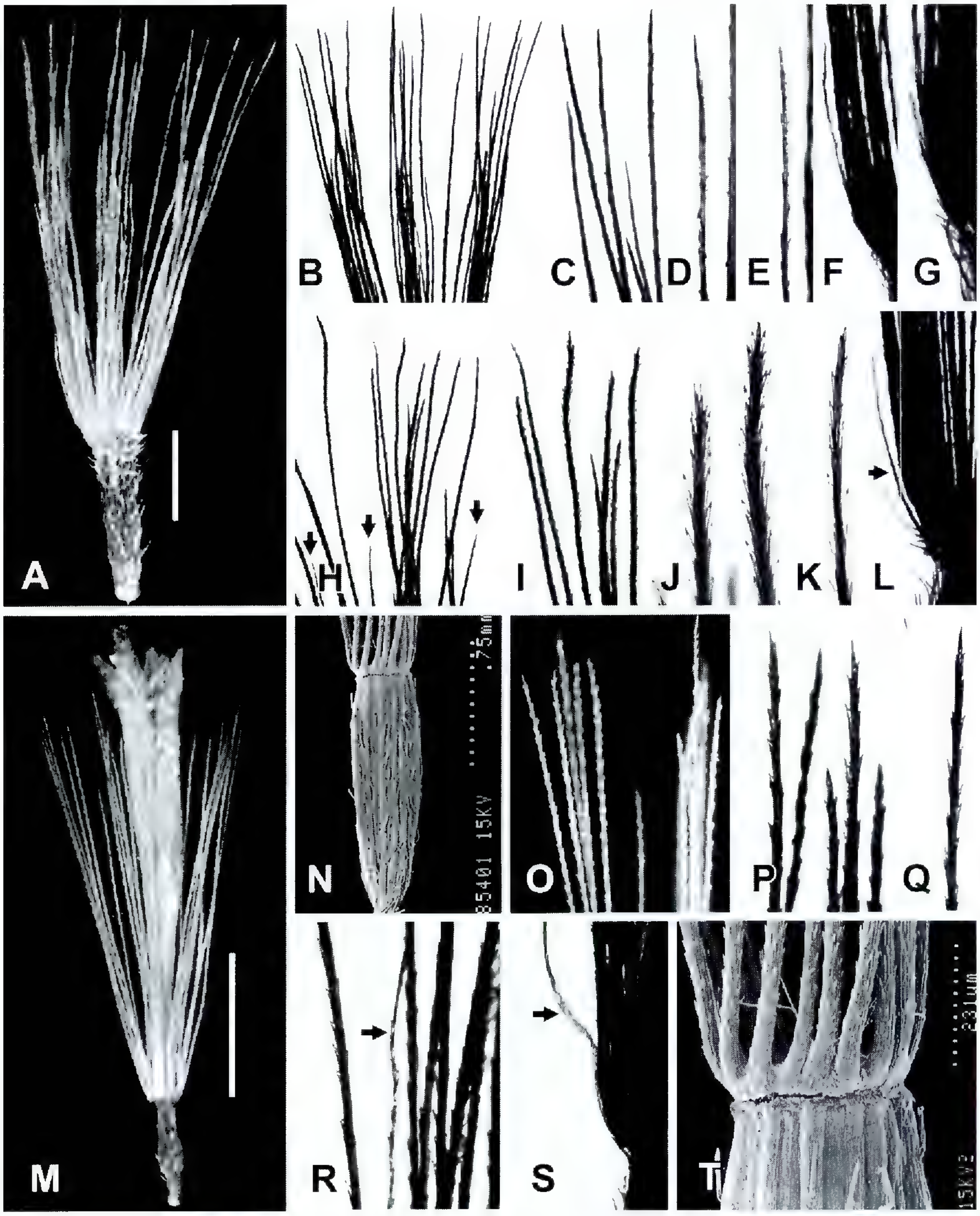


FIG. 8. Fruit and pappus traits in *Osbertia*, disc fruits; scale bar = 1 mm. **A–G.** *O. stolonifera* (*Ton 1027* TEX-LL). **A.** Immature fruit. **B.** Distal portion of longer bristles. **C.** Very weakly clavate primary inner bristles. **D–E.** Tips of mid length secondary outer bristles. **F–G.** Short and very short secondary outer bristles, respectively. **H–L.** *O. chihuahuana* (*Gonzales & Acevedo 2232* TEX). **H.** Distal half of pappus (arrows indicate possible secondary inner bristles). **I.** Distal portion of primary bristles. **J.** Tips of primary inner bristles. **K.** Tip of possible secondary inner bristles (center in H). **L.** Linear secondary outer bristle (arrow). **M–T.** *O. bartlettii* (*Nesom 6296* WAT; SEM images, *Muller 2854* UC. **M.** Immature fruit with disc corolla attached. **N.** Fruit body (SEM). **O–Q.** Tips of long primary bristles. **R–S.** Tip and base of rarely seen short outer bristle, respectively. **T.** Proximal portion of uniseriate pappus (SEM).

reported above was found on one fruit of the few present on the single collection of the species at WAT (*Nesom 6296*), but none were visible in the material from UC used for the SEM examination (Fig. 8H).

The phylogenetic position of *Osbertia* is uncertain and the genus only tentatively has been included here in the Chrysopsidinae. It was included in *Haplopappus* sensu lato by Hall (1928), which sensu stricto is part of the Machaerantherinae Nesom. Nesom (1991c) placed *Osbertia* in the Chrysopsidinae, and Nesom (2000) placed it close to *Chrysopsis*. In the RFLP DNA study by Lane et al. (1996), *Osbertia stolonifera* was placed basal to the clade including *Ericameria*/*Macronema*, *Xylothamia*, and *Tonestus* but was not included in the ITS DNA sequence study by Beck et al. (2004). In the latter study, *Ericameria*, *Xylothamia*, and *Tonestus* were each placed in different clades separate from the clade including *Heterotheca villosa* and *Chrysopsis gossypina*. The phylogenetic position of *Osbertia* within the North American clade needs additional study. On the basis of pappus traits, *Osbertia* fits into the subtribe Chrysopsidinae as a derived lower base number taxon with a reduced number of bristles, sometimes reduced number of series, and derived non-clavate to weakly clavate longer bristles. Further study is needed to determine if such traits would exclude it from other proposed subtribes.

SYSTEMATICS IMPLICATIONS

There is considerable variation in the pappi traits of taxa within the Chrysopsidinae, which can not be defined in part on the basis of usually having a double pappus. Even within individual genera there is variation in the number of series, how distinct the series are from each other, and the number of long bristles per fruit. There are patterns to the variation such that a "norm" for each genus can be given, but these are not diagnostic due to with-genus variation and overlapping of ranges of variation between genera. For example, the number of bristles in *Noticastrum*, with a quadruple pappus, is higher compared to other genera; the bristles in all series are linear; and the tips of the longest secondary inner bristles differ little from those of the shorter bristles in the primary outer series and secondary inner series. In *Heterotheca* with a usually quadruple pappus, the number of bristles averages less than *Noticastrum* but more than occur on the fruits of the lower base number taxa; and there are usually only a few mid-length bristles making up the secondary outer whorl. However, in *H. oregona* the number of bristles is within the range found in *Noticastrum*, but the series are generally discontinuous in length and thus do not grade into each other. In other species of *Heterotheca*, the bristle series grade into each other, but there are fewer bristles, e.g., *H. thiniicola*. In *Chrysopsis* with a usually triple pappus, the number of bristles and the absence of secondary inner bristles is fairly consistent; the primary inner bristles usually are more obviously clavate than in most species in other genera of the

subtribe; and fruits with relatively broad secondary outer scales have some linear scales. *Chrysopsis mariana* with $x = 4$ has a double pappus or "slightly" triple pappus (1–2 primary inner bristles), while the secondary outer scales are like other species in the genus and the primary inner bristles are obviously clavate (especially when examined at 50–100H). Although pappus descriptions of the genera of the Chrysopsidinae need to be longer to encompass the details and range of variation in the series of bristles, the individual genera themselves can not be diagnosed on the basis of pappus traits alone. Therefore, the details of pappus features presented here are likely to be more significant for cladistic/phylogenetic studies then for identifying specimens. The genera with the higher base numbers have more pappus elements in more series than do the lower base number genera with more derived and simpler pappi. Lastly, when the pappi of members of other subtribes have been examined in detail, general trends in differences of derived features may emerge. At this point, however, more data are needed.

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Book Review

Bobby J. Ward. 2004. **The Plant Hunter's Garden.** (ISBN 0-88192-696-5, hbk.). Timber Press Inc. 133 S.W. Second Ave, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax). $39.95, 340 pp., b&w drawings, color photos, bibliography, index, 7 3/8" × 10 3/8".

If you get excited at the sight of the season's first seed and plant catalogs, you should pick up a copy of the new book *The Plant Hunters Garden*. Author Bobby Ward includes the profiles of 32 modern day plant hunters, the persons responsible for many of the plant offerings in those catalogs. The people included are from throughout the world and are associated with an assortment of nurseries, horticultural research associations, and/or small companies offering plants or seeds. The focus of the included plant collectors is very diverse: native plants, regional plants, "hardy" plants, rock and alpine gardens, plants/seeds from inaccessible locales, unusual or hard to find species or varieties, and even collectors with very specific interests, such as bulbs, shade plants, and single genera.

Each chapter focuses on one plant hunter/company. First off, the person or company is profiled giving some background information on the collector's history and plant interests. Then some information on travels and exploration for new plants is discussed. A conclusion for each includes a picture of the collector and company contact information. The bulk of each chapter concentrates on the plants collected by, introduced by, grown by and promoted by the various plant hunters. The chapters are filled with colorful photos of plants, as well as some origin descriptions and growing zone information for various plants. Throughout the chapters are brief stories about how some plants were discovered or how the person met someone who introduced or passed along the plant to them. The descriptions of the discovery of these plants were a little less adventurous than this reader expected, but these discoveries are still interesting to read about. An example of such a discovery is that of the small, white flowered, bronze leaved plant *Jabrosa volkmannii* by John Watson and Anita Flores, found growing in pumice on the side a volcano. There is also interesting information on how these hunters cultivate their finds. For instance the book includes a few "rock gardeners" growing species in various rock crevices including Panayoti Kelaidis of the Denver Botanical Gardens who designed and manages a 450,000 kg, 0.4 ha rock garden with 4000+ plant species. The book concludes with a chapter on invasive plants that gives an honest look at what weeds and invasive species are and the variety of vectors of their introduction.

If you are a gardener or horticulturalist who thrills at the anticipation of new species and varieties of plants, you will thoroughly enjoy reading this book and will benefit from the contact information supplied for each collector. Travel with these plant hunters to exotic locales to share the thrill of discovery, excitement of their plant finds and cultivation experiences within the pages of Ward's The Plant Hunter's Garden. *-Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

NOTES ON TYPES IN APOCYNACEAE: ASCLEPIADOIDEAE IN CUBAN HERBARIA AND FOUR LECTOTYPIFICATIONS IN WEST INDIAN GONOLOBINAE

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ABSTRACT

Four asclepiadaceous types not listed in a previous type catalogue of the collections of the Instituto de Ecología y Sistemática, Habana, Cuba (HAC) are provided, along with a discussion of typification problems associated with the associated Charles Wright collections. Lectotypifications are provided for *Gonolobus stephanotrichus* Griseb., *Orthosia acuminata* Griseb., *Orthosia oblongata* Griseb., and *Poicilla ovatifolia* Griseb.

RESUMEN

Se aportan cuatro tipos de Asclepiadaceae no listados en el catálogo previo de tipos de las colecciones del Instituto de Ecología y Sistemática, Habana, Cuba (HAC), junto con una discusión de los problemas de tipificación asociados con las colecciones Charles Wright. Se aportan lectotipificaciones de *Gonolobus stephanotrichus* Griseb., *Orthosia acuminata* Griseb., *Orthosia oblongata* Griseb., y *Poicilla ovatifolia* Griseb.

A revision in progress by Krings of subtribe Gonolobinae (Apocynaceae: Asclepiadoideae) in the West Indies has led to the discovery of four additional types at the Instituto de Ecología y Sistemática, Habana, Cuba (HAC). These specimens were not listed in a previous catalogue of types at HAC (Cardenas & Herrera 1991). Types in subtribe Gonolobinae were not found at the Jardín Botánico Nacional, Habana (HAJB; for a complete list see Gutiérrez et al. 1997). The expanded list of Apocynaceae: Asclepiadoideae types at HAC is presented in Table 1.

The asclepiadaceous original material at HAC belongs to two groups: (1) species with unproblematic typification due to designations by the original author(s) and (2) species requiring lectotypification due to complications in collecting practice and lack of holotype designations.

Typification is unproblematic for *Marsdenia micrantha* Alain, *Matelea alainii* Woodson, and *Marsdenia bicolor* Britton & P. Wilson, as these species were described relatively recently and as each original author designated holotypes. Thus, corresponding material at HAC (Table 1), was identified easily as either holotype, isotype, or paratype based on the respective protologues. An

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TABLE 1. List of Apocynaceae: Asclepiadoideae types at the Instituto de Ecología y Sistemática, Habana, Cuba (HAC). Previously unlisted types (Cardenas & Herrera 1991) are marked by an asterisk.

(1) Species with unproblematic typification
**Marsdenia bicolor* Britton & P. Wilson, Bulletin of the Torrey Botanical Club 50:47. 1923. TYPE: CUBA: *Léon 10787* (ISOTYPE: not seen); *Léon 10788* (PARATYPE!)
Marsdenia micrantha Alain, Revista de la Sociedad Cubana de Botánica 13:59. 1956. TYPE: CUBA: *Alain, Acuña & López 5678* (HOLOTYPE; ISOTYPE: not seen)
Matelea alainii Woodson, Contribuciones Ocasionales del Museo de Historia Natural del Colegio "De La Salle" 15:23–24. 1956. TYPE: CUBA: *Alain & Morton 5029* (ISOTYPE!)
(2) Species lectotypified herein (see text)
Gonolobus stephanotrichus Griseb., Catalogus plantarum cubensium 177. 1866. TYPE: CUBA: *Wright 2969* (SYNTYPE!)
**Orthosia acuminata* Griseb., Catalogus plantarum cubensium 175. 1866. TYPE: CUBA: *Wright 2966* (ISOLECTOTYPE!)
**Orthosia oblongata* Griseb., Catalogus plantarum cubensium 176. 1866. TYPE: CUBA: *Wright 2967* (ISOLECTOTYPE!)
**Poicilla ovatifolia* Griseb., Catalogus plantarum cubensium 177. 1866. TYPE: CUBA: *Wright 2965* (SYNTYPE!)

isotype of *Marsdenia bicolor* was reported previously by Cardenas and Herrera (1991), but not seen as part of this study. A paratype (*Léon 10788*) at HAC was not listed by Cardenas and Herrera (1991).

Grisebach (1866) described a number of taxa based on material collected by Charles Wright in the Antilles. These included the following four species for which original material was found at HAC and for which lectotypification is necessary: *Gonolobus stephanotrichus* Griseb., *Orthosia acuminata* Griseb., *Orthosia oblongata* Griseb., and *Poicilla ovatifolia* Griseb. (Table 1).

Grisebach studied Wright material distributed to him by Asa Gray (GH). However, these specimens were not necessarily true duplicates of a single gathering. Indeed, there have been instances of mixed material joined by a single number, as Gray appears to have provided the same number to specimens Wright may have collected from different locations on different dates (Howard 1986, 1988). Thus, Howard (1986) stated [brackets ours]:

"The determination of the type collection, therefore, depends on examining the sheet Grisebach saw and named, which is preserved in Göttingen [GOET, Universität Göttingen]. This should match one of the fragments preserved by Gray. The GOET specimens however, rarely have field tickets, so the date and location of the type collection can only be determined, if at all, from the GH sheet."

Howard (1988) noted that Grisebach likely did not see the Wright collec-

tions sent to the Sauvalle herbarium in Habana (currently deposited in HAC), as Asa Gray distributed this material from GH. In contrast to Howard (1988), however, it should be noted that the fact that Grisebach may not have seen the Wright specimens in the Sauvalle herbarium, has no bearing on their status as original material and availability for lectotypification in the future. If judged only by this fact, according to Div. 2, Ch.2, Sect. 2, Art. 9 of the International Code of Botanical Nomenclature or ICBN (Greuter et al. 2000), they would nonetheless be considered part of the original material and, as duplicates of one cited collection, would be syntypes as articulated by Fantz (1993).

Gonolobus stephanotrichus.—Two specimens of *Wright 2969* reside at GOET!. No field tickets accompany the GOET specimens. Both sheets include flowers and one also includes a fruit. Fruits are not described in Grisebach's protologue. Duplicates of this number are found at BREM!, G!, GH!, HAC!, K!, NY!, P!, UC!, US!, and reported for MO, although this specimen could not be obtained on loan. The collection labels of the sheets at GOET are blue and bear the dates 1856–7 crossed out. No additional dates are given. The collection labels for duplicate numbers housed everywhere else, but HAC, are white and bear the dates 1860–64 (including the MO specimen, an image of which could be seen from the Missouri Botanical Garden website: http://www.mobot.org). The collection label for the HAC specimen is white and bears the date 1865. This specimen is sterile and quite poor due to insect damage. Field tickets remaining with the sheet at GH seem to indicate that the three mounted fragments (all in flower) were collected at different times (Jan., Mar., Apr.). However, it is impossible to tell which fragment is associated with which field ticket and furthermore, none can be correlated with the GOET sheets, as these lack field tickets altogether. All material under the number *2969* (incl. the duplicate at HAC) does appear to belong to the same species. Thus, in light of the available facts, the *Wright 2969* sheet at GOET that bears flowers, but lacks fruit, is herein designated lectotype for *Gonolobus stephanotrichus* Griseb. This action agrees with a 1984 annotation by R.A. Howard whose lectotypification (1988) appeared in a microfiche appendix, not in print, and thus is not effectively published and has no standing in nomenclature. Rankin & Greuter (2000) reported a similar case in Antillean *Aristolochia*. The remaining extant sheets distributed under *Wright 2969* retain their status as syntypes. An additional fruiting specimen of *Gonolobus stephanotrichus* is housed at S, bearing a Wright label of 1861 and the preliminary number 164. Although a determination on the label is provided in Grisebach's hand, we do not consider the specimen original material as fruits were not mentioned in the protologue.

Orthosia.—The only known type material for *O. acuminata* (*Wright 2966*) is deposited at BM, G, GH, HAC (2 sheets), and K. These specimens bear white labels with the dates 1860–64. The mounted field ticket on the GH sheet reads:

"Asclepias—Fl. (except the white stigma) green. Farallones San Andre Oct 27." As *Wright 2966* (GH!) contains fifteen inflorescences and is in very good condition; it is here designated as the lectotype for *Orthosia acuminata* Griseb. *Wright 2966* (G!) contains four inflorescences and is in superior condition to the HAC material. *Wright 2966* (BM!, G!, HAC!, K!) should be considered isolectotypes.

Original material of *Orthosia oblongata* was located at BM!, G!, GH!, HAC!, K!, and S!, and reported for MO, although the specimen could not be obtained on loan. These specimens all bear white labels with the dates 1860–64 (including the MO specimen, an image of which could be seen from the Missouri Botanical Garden website). The mounted field ticket of *Wright 2967* (GH) reads: "Asclepias—Fl. green—a white speck at the tips of the segments. Stigma white. Loma de Ranjel June 17." Field tickets do not accompany the other specimens. *Wright 2967* (GH) is herein designated lectotype for *Orthosia oblongata* Griseb., considering the duplicates at G, HAC, K, MO (provided that the specimen does not constitute another species), and S isolectotypes. *Wright 2967* (GH) is in good condition, with numerous inflorescences.

Lectotypification decisions for both *Orthosia* names were based on the interpretation that sheets of both *Wright 2966 & 2967* are original material, as they were respectively cited in the according protologues. There is no evidence that they were collected from different localities, although this cannot be ruled out altogether, given the notorious problems with Wright collections. However, in our opinion, when there is no specific evidence to the contrary, if collection number and identification match, the protocol ought to hold that the specimens be considered duplicates of a single gathering. We recognize that "isolectotype" is not an ICBN type designation, but assign it herein should lectotypes become lost or destroyed or additional syntypes are located that we have not examined.

Poicilla ovatifolia.—Syntype material (*Wright 2965*) was located at BM!, BREM!, G!, GH!, GOET!, HAC!, K, NY!, P!, S!, and UC! No field tickets accompany the GOET specimen or any syntype, except the GH specimen. Accompanying field tickets of the GH specimen suggest that the sheet is comprised of at least two collections made at different times (Mar., June), although three fragments are mounted. The two fragments mounted on the right contain inflorescences; the fragment mounted on the left contains infructescences. Both field tickets refer to flowers with neither one mentioning fruits. Fruits are not described in Grisebach's protologue and are not present on any other syntype beside the GH specimen. Except for the GOET specimen, collection labels of all other known specimens are white and bear the dates 1860–64. The GOET specimen bears a tan label with a printed date of 1860, although the zero appears to have been crossed out. It is heavily written on in Grisebach's hand and is herein designated lectotype for *Poicilla ovatifolia* Griseb. The studied (and matching) duplicately-numbered material in other herbaria remain syntypes.

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Book Review

John Dawson and Rob Lucas. 2005. **The Nature of Plants: Habitats, Challenges & Adaptations.** (ISBN 0-88192-675-2, hbk.). Timber Press Inc. 133 S.W. Second Ave, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax). $39.95, 314 pp., 205 color photos, 5 color drawings, glossary, and index, 7.38" × 10.38".

The new book called *The Nature of Plants* is a plant lover's dream. Have you ever wondered how it's possible for any plants grow in the tundra? Or how underwater plants get their flowers pollinated? The authors have provided readers with a wonderful resource to answer these and many of other questions about plants surviving in extreme environments. The text is peppered with rich color photographic examples of the plants and landscapes described in the text.

In each chapter, the reader is introduced to unique environments, conditions, and climates; and then told about all the special challenges faced by plants that live there. For example, we're told about parasitic plants, desert plants (both hot and cold), fire effects, salt water plants, plants on windy terrain, plant interactions with animals, fungal and even bacterial interactions between the plants.

The authors provide a good informational background for the reader regarding the environmental and climatic situations of the plants. For example, in one chapter titled "Not Enough Water" the authors include an explanation of why deserts even exist and where they're located. This book covers a lot more than just North America when they go into detail on the deserts of the world including temperate deserts and the special adaptations that plants make for each environment.

Reading about the plant adaptations to these challenging environments makes this book particularly interesting. After a basic description of climates or special conditions, the author includes information about common plant survival strategies. For example, the chapter about fire shows how some plants use fire as a regeneration process; after being damaged, they release seeds or flower. Very often, the strategies are given with specific plant examples along with beautiful color photographs that help the reader visualize such reactions/adaptations These images are especially wonderful because many of the images show plants in exotic locations. In addition, one chapter focuses on the various methods of reproduction and the different vectors for pollen transfer. This chapter included a wonderful discussion on the benefits and problems of self-pollination and out-crossing in plants.

The book *The Nature of Plants: Habitats, Challenges & Adaptations* is recommended for anyone with an interest in plants and their ability to survive in even the harshest of habitats. This book does not require much botanical background to enjoy, although an understanding of plant family traits will be helpful. A glossary is included for the less common terminology. All topics are explained with diverse examples and fantastic color photographs. Read *The Nature of Plants: Habitats, Challenges & Adaptations* and take a peek into the fascinating survival strategies of plants in extreme situations and environmental conditions.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

COMMENTS ON THE *GERBERA*-COMPLEX (ASTERACEAE: MUTISIEAE)

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ABSTRACT

The recent transfer of *Chaptalia hintonii* to *Gerbera* is doubted, as is any transfer of New World members to the Old World part of the *Gerbera*-complex. On a biogeographic basis it seems more probable that *Gerbera* is an Old World clade, while *Chaptalia*, *Trichocline*, and *T. hieracioides* (sometimes considered to be a *Gerbera)* are New World groups. The geographic distribution of *Leibnitzia* (North America, Asia) and *Amblysperma spathulata* (W. Australia) is enigmatic. Additional input of data is needed for a full understanding of the phylogeny in the *Gerbera*-complex.

RESUMEN

La reciente transferencia de *Chaptalia hintonii* a *Gerbera* es dudosa, como lo es cualquier transferencia de elementos del Nuevo Mundo a la parte del complejo *Gerbera* del Viejo Mundo. En base a la biogeografía parece más probable que *Gerbera* es un clado del Viejo Mundo, mientras que *Chaptalia*, *Trichocline*, y *T. hieracioides* (a veces considerado como una especie de *Gerbera)* son grupos del Nuevo Mundo. La distribución geográfica de *Leibnitzia* (Norte América, Asia) y *Amblysperma spathulata* (Oeste de Australia) es enigmática. Se necesitan datos adicionales para una completa comprensión de la filogenia del complejo *Gerbera*.

In recent papers, Katinas (1998, 2004b) and Nesom (2004a,b) discussed the generic position of *Chaptalia hintonii* Bullock within the *Gerbera*-complex (the scapose complex of Mutisieae subtribe Mutisiinae sensu Cabrera 1977). Their discussion continues the long-standing debate regarding OTUs within this complex. To recapitulate briefly, Jeffrey (1967) used LM to point out characters of taxonomic value in the group, mainly pertaining to cypselar pubescence and pappus-hairs. When I took up similar studies (e.g., Hansen 1985, 1990) SEM had been introduced, but my conclusions deviated little from those of Jeffrey.

Nesom (1983) contributed with his first study of the *Gerbera*-complex (American *Leibnitzia)* and next focused on *Chaptalia* Vent. (Nesom 1984a,b, 1995, 2004a,b; Cabrera & Nesom 2003), while other workers have also published studies dealing with the scapose group (Katinas 1998, 2004a,b; Sancho & Katinas 2002; Moraes 1998; Hind 1999, 2001; Roque 2005). All these studies, with their general access to living material, have amplified our knowledge about the *Gerbera*-complex.

The complex includes about 100 species, and evidently it takes subtle char-

acters to delimit monophyletic groups within it. This is noteworthy in view of its wide distribution: *Trichocline* Cass., *Lulia* Zardini, and *Chaptalia* Vent. in the New World, *Leibnitzia* Cass. in North America and Asia, *Gerbera* L. in Africa, Madagascar, and Asia (i.e., *Gerbera* sensu Hansen 1990), *Perdicium* L. in W. Cape, *Uechtritzia* Freyn in Asia, and *Amblysperma spathulata* (A. Cunn. ex DC.) D.J.N. Hind in W. Australia. It has been disputed whether *Amblysperma* falls within the limits of *Trichocline* (Hind 2001, and implicitly Hansen 1990, *contra* Zardini 1975 and Katinas 2004a), and whether the transfer of *Trichocline hieracioides* (Kunth) Ferreyra (Ecuador, Peru) to *Gerbera* by Zardini (1974) is correct. The most significant problem, however, is with *Chaptalia*, for which no complete revisionary treatment exists; Burkart (1944) only considered part of the genus in detail.

Nesom (2004a) and Katinas (2004b) remarked that while Jeffrey would split the complex into smaller genera, I suggested the recognition of one large genus (hence *Gerbera*). This calls for an explanation. The relatively ancestral position within Asteraceae of Mutisieae (however circumscribed, but at least excluding subfamily Barnadesioideae (Benth. & Hook.f.) K. Bremer & R.K. Jansen) is now supported by morphologic and molecular evidence. Of relevance here is that part of the classic Mutisiinae in all studies is indicated to be monophyletic, with the *Gerbera*-complex placed in a relatively advanced position. Actually, the Brazilian monotypic genus *Lulia* (Zardini 1980) (i.e., *Trichocline nervosa* Less.), by its monocephalous, albeit non-scapose habit, stands between the *Gerbera*-complex and its sister (a group including *Mutisia* L.f., *Chaetanthera* Ruíz & Pav., *Duidaea* S.F. Blake, and *Pachylaena* D. Don in Kim et al. 2002; *Lulia* was not considered).

In Hansen (1991), I anticipated these aspects and then reasoned that if *Mutisia* and *Chaetanthera* are not split into minor taxonomic units, it would not be logical to split the *Gerbera*-complex either, hence all species should fall within *Gerbera*. This explains my way of reasoning which was *not* versus Jeffrey (1967), but simply an alternative provided by cladistic reasoning.

Katinas (2004b:938–939) presented a key to the scapose group with seven genera (including *Lulia*, but with *Amblysperma* sunk into *Trichocline* and awaiting a complete revision of *Chaptalia*). In this key there were autapomorphies for each genus (if we accept that *Trichocline* has a special type of cypsela hairs). However, there is a complication in Katinas's key couplet 6, since *Gerbera* p.p. (sects. *Gerbera*, *Parva*, and *Isanthus*) do not have the apomorphic state 'trimorphic rays.' This is precisely where the problems with *Gerbera* (in its current sense) arise.

Nesom (2004a, cf. Nesom 1995; Cabrera & Nesom 2003) has maintained that *Chaptalia hintonii* belongs to *Chaptalia* sect. *Chaptalia*. The traits which led Katinas to move it to *Gerbera* (all florets bilabiate, outer ray florets long, ray florets with staminodes) can be found in various *Chaptalia*, and the cypsela

hairs in *C. hintonii* do not deviate in morphology from those in *Chaptalia* sect. *Chaptalia* p.p. (the *C. lyratifolia* group).

I believe that Nesom has the strongest point, namely that the 'deviating' traits in *C. hintonii* do not disrupt its alliance with *Chaptalia* sect. *Chaptalia*. Rather, *C. hintonii* possesses states which are parallelisms/reversals to those in *Gerbera*. As Nesom indirectly argues, it seems more probable on a biogeographic basis that *Gerbera* is an Old World clade, while *Chaptalia*, *Trichocline*, and the enigmatic *T. hieracioides* are New World groups (not overlooking problems with *Amblysperma* in W. Australia and *Leibnitzia*, which is divided between Asia and North America).

Evidently, various authors during their close survey of taxa detect exceptions to the currently used taxonomy and thus find reason to allocate this or that species. But the question is whether we push the case too far. We know more today than we did in Hansen (1990) and hardly disagree on the polarization of states. Hence, a matrix with all relevant placeholders in the *Gerbera*-complex treated as OTUs ultimately should be prepared, because only then it will be revealed, if the addition of new characters can disrupt the unity of (some of) the currently recognized taxonomic groups. Presumably, however, the consensus tree will still be burdened with polytomies, since the number of known synapomorphies is so small. Additional input of data is therefore much welcome. However, along with the detection of amplified variation in ray floret morphology, cypselar vestiture, etc., the selection of relevant characters may cause more and more debate. A good example is the presence of trichomes on corollas in 13 species of *Trichocline*, three of *Onoseris*, and one investigated species of *Uechtritzia* (Sancho & Katinas 2002). Is this information of phylogenetic relevance or not?

Nesom (2004a:932) has now suggested that *Chaptalia* sects. *Lieberkuhna* (Cass.) Burkart and *Loxodon* (Cass.) Burkart possibly may be separated at generic rank, among other things due to their distinctive cypselar vestiture. Katinas (2004b) likewise predicted taxonomic alterations at generic rank. The discussion between the two authors reveals considerable disagreement, both with respect to observation of characters (e.g., whether ray flower staminodes are present or not) and how to interpret their phylogenetic relevance. I must stay neutral, since I never studied *Chaptalia* in detail, but clearly the main issue is to decide whether *Chaptalia* is monophyletic (even if split into two genera), with evolution of character states parallel to those in *Gerbera*, or whether some species of *Chaptalia* really should be moved to *Gerbera* or even something else.

ACKNOWLEDGMENTS

I thank Guy Nesom and an anonymous reviewer for their most insightful comments which improved much on this paper.

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Book Review

Helen Heibert. 2006. **Papermaking with Garden Plants and Common Weeds. (Paperback edition).** (ISBN 1-58017-622-4, pbk.). Storey Publishing, 210 MASS MoCA Way, North Adams, MA, 01247, U.S.A. (**Orders:** # 67622, 1-800-441-5700, www.storey.com). $14.95, 112 pp., color photos, drawings, appendix, glossary, resource guide, index, 9 1/4" × 10".

Papermaking With Garden Plants And Common Weeds is a good resource for crafters and professionals interested in making their own paper from natural materials. Author Helen Heibert has put together a wonderful reference with step-by step instructions on three methods of papermaking with a variety of natural materials. These instructions include practical advice on keeping records of results with different materials, detailed fiber processing instructions, and sidebars of personal experiences and successes of the author.

The book begins with preliminary information on responsible and safe plant fiber and material collecting. This introductory information is followed by descriptions of the types of possible fibers: bast, leaves, grass and others materials including purchased and recycle fibers. Next she presents the instructions for making four mould types and describes the accessory equipment required with the different papermaking techniques. For the different alkali recipes, she presents step-by-step processing instructions covering cooking, beating, retting, and safety information. In addition to that, she includes information on the additives for protecting and coloring fiber materials with artificial and natural dyes.

Along with the descriptive instructions, the author has also included great color images that highlight the step-by-step instructions for the three various techniques: Western style with a mould and deckle, Japanese papermaking with a sugeta and formation aid (recipes included), and the Nepalese method using a deckle box. There is a helpful troubleshooting section for potential problems that may be encountered during the paper making process. Multiple pressing techniques are also presented with color images and include instructions on how to make your own paper press as well as wet paper handling suggestions and drying techniques.

The author has included projects with instructions of ten different artists who used ten different plant materials and various methods to create paper. A small personal story box is included with each artist's project. Additionally, seven step-by-step projects are presented including: flower petal paper, embedding objects within paper, vegetable papyrus, envelope, lampshade, and accordion book. Following the section on projects is important information including lists of papermaking plants, with common and Latin names, glossary, reading list, and a resource guide.

Author Helen Heibert has provided adventurous crafters with well-guided instructions on paper-making techniques and projects. The techniques are recommended for adults and, due to the chemicals and cooking involved, children with adult supervision. The paper types and projects suggested and included in the book *Papermaking with Garden Plants and Common Weeds* are promising for scrap booking, card making, craft groups, interior design, education, youth projects and many other potential endeavors.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

VALIDATION OF THE NAME *DAHLIA SUBLIGNOSA* (ASTERACEAE)

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Article 33.3 of the International Code of Botanical Nomenclature (ICBN) (St. Louis Code 2000) states that a new combination based on a previously and validly published name is not itself validly published unless its basionym is clearly indicated and fully referenced. While the original work was cited regarding the new combination of *Dahlia dissecta* S. Watson var. *sublignosa* P.D. Sörensen to *Dahlia sublignosa* (P.D. Sørensen) D.E. Saar & P.D. Sørensen, the basionym was not "clearly identified" (Saar & Sørensen 2005). Therefore, the combination is validated here in accordance with the ICBN.

Dahlia sublignosa (P.D. Sørensen) D.E. Saar & P.D. Sørensen, comb. & stat. nov.

BASIONYM: *Dahlia dissecta* var. *sublignosa* P.D. Sørensen, Rhodora 71:351. 1969. TYPE: MEXICO. Tamaulipas: 4.8 km N of Miquihuana in forest dominated by *Pinus* (99°47' N Lat; 23°36' W Long.), elev. ca. 2100 m, 14 Jul 1949, *Stanford, Taylor, & Lauber 2436* (HOLOTYPE: NY; ISOTYPES: GH, MICH, TEX, UC, US-2, WTU).

As an explanatory note, the holotype specimen collected by *Stanford, Taylor, & Lauber 2436* cited in our paper is a correction of the original basionym, which was incorrectly stated as collected by *Stanford, Rutherford, and Northcroft 2436.*

ACKNOWLEDGMENTS

We thank Teri Bilsborrow for bringing this oversight to out attention and Kanchi Gandhi for helpful comments regarding this validation notice.

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SAAR, D.E. and P.D. SØRENSEN. 2005. *Dahlia sublignosa*: a species in its own right. Sida 21:2161–2167.

Book Review

Frederick R. Troeh and Louis M. Thompson. 2005. **Soils and Soil Fertility. 6th edition**. (ISBN 0-8138-0995-X, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** 515-292-0140, 515-292-3348 fax 1-800-862-6657, www.blackwellprofessional.com, orders@ames.blackwellpublishing.com). $89.95, 498 pp., 231 illustrations, 7" × 10".

Soil and Soil Fertility is a well-illustrated book that presents soil topics in an easily understood language. It would be suitable as a textbook for classes on general soils or soil fertility. Additionally, this title could also be a beneficial reference text for classes in agronomy, hydrology and agricultural engineering.

Within the preface, the authors mention that this book has been "*designed for use as a textbook for the introductory course in soils for students in agriculture and related sciences.*" Chapter topics include **1)** Soil; **2)** Soil Formation; **3)** Physical Properties of Soils; **4)** Soil Mechanics; **5)** Soil Water; **6)** Soil Organic Matter; **7)** Soil Mineralogy; **8)** Soil Chemistry; **9)** Amending the Soil; **10)** Fertilizers; **11)** Nitrogen; **12)** Phosphorus; **13)** Potassium; **14)** Calcium, Magnesium, and Sulfur; **15)** The Micronutrients; **16)** Variations in Plant Composition; **17)** Soil Classification; **18)** Land Use and Soil Management; **19)** Water Management; **20)** Soil Erosion and Its Control; and **21)** Soil Pollution. The order of chapters flow well into one another, building on previous chapters' materials, starting with soils basics and mineralogy, delving in soil chemistry and fertility and ending with environmental topics and land stewardship.

The text is very readable and is accompanied by many supportive illustrations, graphs, and charts. These diagrams and illustrations utilize black and white hatch marks and other easily distinguishable designs. The authors have made the calculations straightforward and typically offer an example problem with explanation. Basic soil tests/analyses are included throughout the text including items such as particle size analysis using Stoke's law, a hydrometer, and a RUSLE soil loss equation example. At the end of each chapter is an important notes section, and a list of questions that if answered, would demonstrate an understanding of the text.

In addition to all of the discussion of general soils information, this book also delves into two other important soils subjects. soil fertility and soil classification. The section on soil fertility is a very straightforward and usable introduction to soil fertility followed by chapters covering the macro and micronutrients. These chapters include chemical use and deficiency symptoms in plants, the nutrient cycle and availability, fertilizer types for that nutrient, application info and more. The chapter on soil classification includes a number of different systems with background and explanation on each system, additionally covering land use and land practices to reduce soil loss. In the end, there is a measurement and conversion summary as well as a glossary.

Soil and Soil Fertility by Troeh and Thompson would be an excellent textbook for soils and related classes. This is a very intelligent book full of supportive black and white illustrations within the text. Although designed as a textbook, gardeners and enthusiasts may enjoy reading this text for information and a better understanding of soil properties and soil fertility.—*Lee Luckeydoo, Her-*

A NEW COMBINATION IN *POLYTRICHASTRUM* (BRYOPHYTA: POLYTRICHACEAE)

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ABSTRACT

The new combination *Polytrichastrum alpinum* var. *sylvaticum* (Menzies) G.L. Merrill is provided.

RESUMEN

Se aporta la nueva combinación *Polytrichastrum alpinum* var. *sylvaticum* (Menzies) G.L. Merrill.

The following transfer is proposed for use in a treatment of the moss family Polytrichaceae in the *Flora of North America North of Mexico*, vol. 27, the first of the projected three bryophyte volumes. Additional discussion will be found in the flora treatment.

Polytrichastrum alpinum var. **sylvaticum** (Menzies) G.L. Merrill, comb. nov.

BASIONYM: *Polytrichum sylvaticum* Menzies, Bot. Zeit. (Regensburg) 1:74. 1802. TYPE: U.S.A.: Northwest Coast of North America, *Menzies* (HOLOTYPE: E!).

Pogonatum alpinum var. *sylvaticum* (Menzies) Lindberg, Bot. Not. 1867: 130. 1867. *Polytrichum alpinum* var. *sylvaticum* (Menzies) Lindberg, Acta Soc. Sci. Fenn. 10:6. 1872, "*silvaticum*."

Polytrichum macounii Kindberg in Macoun, Bull. Torrey Bot. Club. 16:96. 1889; *Pogonatum macounii* (Kindberg) Kindberg & Macoun, Cat. Canad. Pl. 6:152. 1892. *Pogonatum alpinum* var. *macounii* (Kindberg) Cardot & Thériot, Proc. Wash. Acad. Sci. 4:328. 1902. *Polytrichum alpinum* var. *macounii* (Kindberg) Saito, J. Jap. Bot. 31:75. 1956. *Pogonatum alpinum* subsp. *macounii* (Kindberg) Persson in Persson & Viereck, Lindbergia 9:16. 1983.

Habitat and distribution in North America.—On soil in moist woods, common in the lowlands, to middle elevations; British Columbia, southern Alaska, Oregon, Washington.

Polytrichastrum alpinum is a widespread, polymorphic species, common at middle to upper elevations throughout the North Temperate zone, in south temperate South America, the Antarctic, and Australasia. The var. *sylvaticum* is a giant form of the Pacific Northwest with stems as much as 14 cm high, simple to laxly branched, sharply serrate leaves to 19 mm long, and large, plump, cylindric capsules, often somewhat zygomorphic and widest below the middle.

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Book Review

Steven Carroll and Steven Salt. 2004. **Ecology for Gardeners.** (ISBN: 0-88192-611-6, hbk.). Timber Press Inc. 133 S.W. Second Ave, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax). $29.95, 420 pp., 11 b&w figures, 170 color photos, glossary, and common, scientific and subject indices, 6" × 9".

With *Ecology For Gardeners*, authors Steven Carroll and Steven Salt have written a book that is essential for any gardener's shelf. Their book keeps ecological principles in mind while dealing with the subject of gardening.

Ecology for Gardeners provides readers with many points to pause and think about. It contains many cause & effect situations and also presents relationships between abiotic and biotic factors in your garden. The text includes discussion of seemingly unrelated topics that one may not instinctively link together at first; such as how soil temperature relates to nutrient availability for plants, intraspecific competition and plant spacing, pruning as herbivory, energy roles in a garden, the ability of the wind to alter the shape a garden, the importance of microbes to the nutrient cycling & availability in the garden, etc. Chapter topics include plant biology, non plant garden inhabitants, the garden environment, plants and their environment, interactions among garden inhabitants, and gardening as applied ecology (stewardship and garden management).

Each chapter begins with a basic and easy to understand introduction about the topic. After the introduction for each chapter, the topic is divided into well-organized subtopics. For example, the chapter interactions among garden inhabitants include subtopics of competition, herbivory, predation, parasitism and mutualism. Another example is the garden environment chapter that is divided into sun, air, water, soil, energy, food webs, and nutrient cycles within the garden system. The subtopics expand with plentiful details specific to each subtopic itself. Representative of this style is the chapter on applied ecology in gardening; included is a subtopic of energy management. It contains a discussion on mulching varieties, benefits and drawbacks for each mulch type. The chapter on applied ecology in the garden really helps the reader bring together all the previous information of other chapters and may lead to many "Eureka!" moments. Clear color photographs exemplify many of the various plants, items, and occurrences referenced within each chapter.

The book *Ecology for Gardeners* is full of many thought provoking topics; especially for commonly used gardening strategies and the ecological basis behind them. The authors have done a fantastic job of making the ecological part of gardening very accessible to gardeners. Readers will definitely understand more of the ecology that occurs in, around, and under the plants in their garden. More importantly, gardeners will be able to make more informed garden management decisions after reading Carroll and Salt's *Ecology for Gardeners.*—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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A NEW COMBINATION IN *TETRAPHIS* (BRYOPHYTA: TETRAPHIDACEAE)

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ABSTRACT

The new combination *Tetraphis pellucida* Hedw. var. *trachypoda*, is proposed to clarify the taxonomic rank of the moss *Tetraphis trachypoda* and to recognize the morphological difference of having a straight, slightly papillose seta. A revised key to the genus, a diagnosis of var. *trachypoda*, and specimens examined are provided.

RESUMEN

Se propone la nueva combinación *Tetraphis pellucida* Hedw. var. *trachypoda*, para aclarar el rango taxonómico del musgo *Tetraphis trachypoda* y para reconocer las diferencias morfológicas de tener una seda derecha ligeramente papilosa. Se ofrece una clave revisada del género, una diagnosis de la var. *trachypoda*, y los especimenes examinados.

Kindberg (1893) described *Georgia trachypoda* from specimens collected by John Macoun in British Columbia as follows: "leaves subovate or ovate-oblong, short-acuminate and acute. Perichaetial leaves with long, sublinear, acute acumen; costa not excurrent. Capsule straight; pedicel straight, rough in the upper part." In 1900 Paris accepted Hedwig's genus *Tetraphis* and *Georgia trachypoda* Kindb. became *T. trachypoda* (Kindb.) Par. Currently *Tetraphis* consists of two recognized species, *T. geniculata* Grig. *ex* Milde and *T. pellucida* Hedw. Because the gametophytes are undistinguishable, these two species are separated by setae characteristics. Since its description, *Tetraphis trachypoda* has been recognized at various taxonomic ranks.

In 1936 Grout combined *G. trachypoda* under *T. geniculata* noting the seta roughness and dismissing the straight seta. He comments that "*T. geniculata* is not materially different in macroscopic appearance from *T. pellucida*, as the seta is not always noticeably bent at first glance and the bend is sometimes absent as in Kindberg's *Georgia trachypoda* (the only difference of importance that he notes in his description). Specimens in the herbarium of the National Museum of Canada, labeled *Georgia trachypoda* and collected at same date and place as the type and probably a part of it, have the seta only slightly roughened and not geniculate, otherwise normal."

Van Der Wijk et al (1969) and Savicz-Ljubitzkaja and Smirnova (1970) followed Grout's lead and also placed *T. trachypoda* under *T. geniculata*. In Russia,

Abramova et al. (1954) regarded *T. trachypoda* as having only a weakly mamillose stalk, and therefore combined it under *T. pellucida*. They did not comment on its distribution in Russia. Crum and Anderson (1981) in their treatment of *Tetraphis*, comment, "Rare specimens with some setae more or less roughened above but not at all geniculate qualify as *Georgia trachypoda* Kindb., which Grout placed in synonymy of *Tetraphis geniculata*. The sporadic occurrence of such plants (in Ontario, Minnesota, Montana and British Columbia at least) in close association with plants with smooth setae seems to indicate that they are anomalous forms of *T. pellucida*." Ignatov and Afonina (1992) in their check-list of mosses of the former USSR also treated *T. trachypoda* as a synomen of *T. pellucida*.

Forman (1962) in his discussion of the family Tetraphidaceae makes no mention of *T. trachypoda* but does comment that "separating the two species of *Tetraphis* is easy when mature sporophytes are present because very few colonies show intermediate sporphytic characters. In such intermediate cases the tuberculate character of the seta is more constant than the geniculate one." Between 1936 and 1992 *T. trachypoda* has been synonymized under both *T. geniculata* and *T. pellucida*.

While examining specimens of *Tetraphis* from North America for the Bryophyte Flora of North America project, it became apparent that an additional morphological feature of the seta could be used to help clarify the confusion surrounding *T. trachypoda*. Although Weber and Simone (1977) determined that the papillose or tuberculate surface of the seta in *T. geniculata* was the result of protruding end-walls of the cells, they did not mention the spiral vs. straight arrangement of the cells. Their paper focuses on the nature of the papillae and does not comment on the fact that the papillae are also the result of the seta cells becoming straight rather than spirally twisted.

Tetraphis pellucida has a straight smooth seta, with all of the cells strongly spirally twisted throughout its length and it is never papillose. The cells of the seta in *Tetraphis geniculata* are spirally twisted up to the point where the bend occurs. Above the bend the cells are straight and conspicuously papillose by projecting cell-end walls. *Tetraphis trachypoda* on the other hand has a straight seta, in which the cells are spirally arranged and interspersed with short sections of cells (or sometimes only a few cells) that are straight, which results in a few papillae on a normally smooth seta. When the type specimen of *T. trachypoda* was examined, this new characteristic was verified.

The change of cell arrangement correlated with papillae and a bend in the seta of *T. geniculata*, and straight, consistently spirally arranged, smooth seta cells in *T. pellucida* appear to be characteristics sufficient to maintain both of these taxa as individual species. *Tetraphis trachypoda* on the other hand appears to be intermediate between *T. geniculata* and *T. pellucida*, but its charac-

teristics are not sufficient to maintain it as a separate species. It is suggested, therefore, that *T. trachypoda* be treated as a variety of *T. pellucida* based on the straight, slightly papillose setae, the outermost cells of which have alternating zones of cells with either spiraled or straight side walls.

Tetraphis pellucida Hedw. var. **trachypoda** (Kindb. ex Paris) Harpel, comb. nov. **(Figs. 1, 2).** *Georgia trachypoda* Kindb., Rev. Bryol. 20:93. 1893. TYPE: CANADA. BRITISH COLUMBIA: Sicamous, 7 Apr 1889, *J. Macoun s.n.* (HOLOTYPE: S!).

Plants in dense turfs or scattered patches, green above, reddish-brown below. Stems 8–15 mm up to 1 cm tall. Leaves erect-spreading, ovate to ovate-lanceolate, 1–2 mm long, keeled, costa subpercurrent, margins entire, plane to broadly recurved, upper medial cells smooth, irregularly rounded-hexagonal, lower basal cells oblong-linear. Stalked, discoid gemmae present in a rosette of rounded bracts (occasionally weakly developed) formed on top of an attenuated stem. Seta 6–14 mm long, erect ± flexuose, cells lightly papillose usually near the base, cells spirally twisted but interspersed with sections of straight cells, twisted when dry. Capsule narrowly cylindrical, 2–3 mm long, peristome teeth 4. Spores 10–17 µm, green to yellowish-green, papillose. Capsules mature in spring to early summer, rare on well rotted wood, stumps and logs.

The distribution of *T. pellucida* var. *trachypoda* is interesting because it occurs in North America and Russia, although at the present time, the geographic range in Russia is unknown. Based on the North American material examined, it appears to only be found in areas where both *T. pellucida* and *T. geniculata* occur, which suggests that it would occur in the Russian Far East where both of these species also overlap. Examination of material from this area and additional fieldwork would help to validate this hypothesis.

Specimens examined: **CANADA. British Columbia:** Sicamour, 7 Apr 1889, *Macoun s.n.* (S). **LABRADOR:** Goose Bay, 10 Jun 1949, *Schofield 32* (NY, UBC). **NEW BRUNSWICK. Restigouche Co.:** Mount Carleton Provincial Park, 12 Aug 1988, *Bristow s.n.* (MICH). **Northwest Territories.** Nahanni National Park, 7 Jul 1974, *Scotter 22554*; 15 Jul 1976, *Steere 76-786, 76-822*; 25 Jul 1974, *Marsh 4550* (NY). **UNITED STATES. COLORADO. Gunnison Co.:** 3 Aug 1969, *Weber B-34769* (COLO, NY). **MONTANA. Lake Co.:** Flathead Lake, 26 Jun 1960, *Schofield 11632* (NY, UBC). **WYOMING.** Yellowstone National Park, 17 Aug 1953, *Welch 16435* (NY). **Teton Co.:** 29 Aug 1973, *Hermann 25571* (NY).

KEY TO SPECIES OF *TETRAPHIS*

1. Seta geniculate, outer cells smooth, and spirally twisted below the bend, cells straight and papillose by projecting cell walls above the bend _____ 1. **T. geniculata**
1. Seta not geniculate, outer cells smooth, and spirally twisted throughout the entire length of the seta, not papillose, or sometimes lightly papillose near the base.
   2. Seta smooth, superficial cells spirally twisted throughout the entire length _____ 2a. **T. pellucida** var. **pellucida**
   2. Seta usually lightly papillose near the base, superficial cells spirally twisted but interspersed with sections of straight cells _____ 2b. **T. pellucida** var. **trachypoda**



FIG. 1. Type of *Georgia trachypoda* Kindb., J. *Macoun s.n.* (S). Size marker in lower right corner equals 2.5 cm.

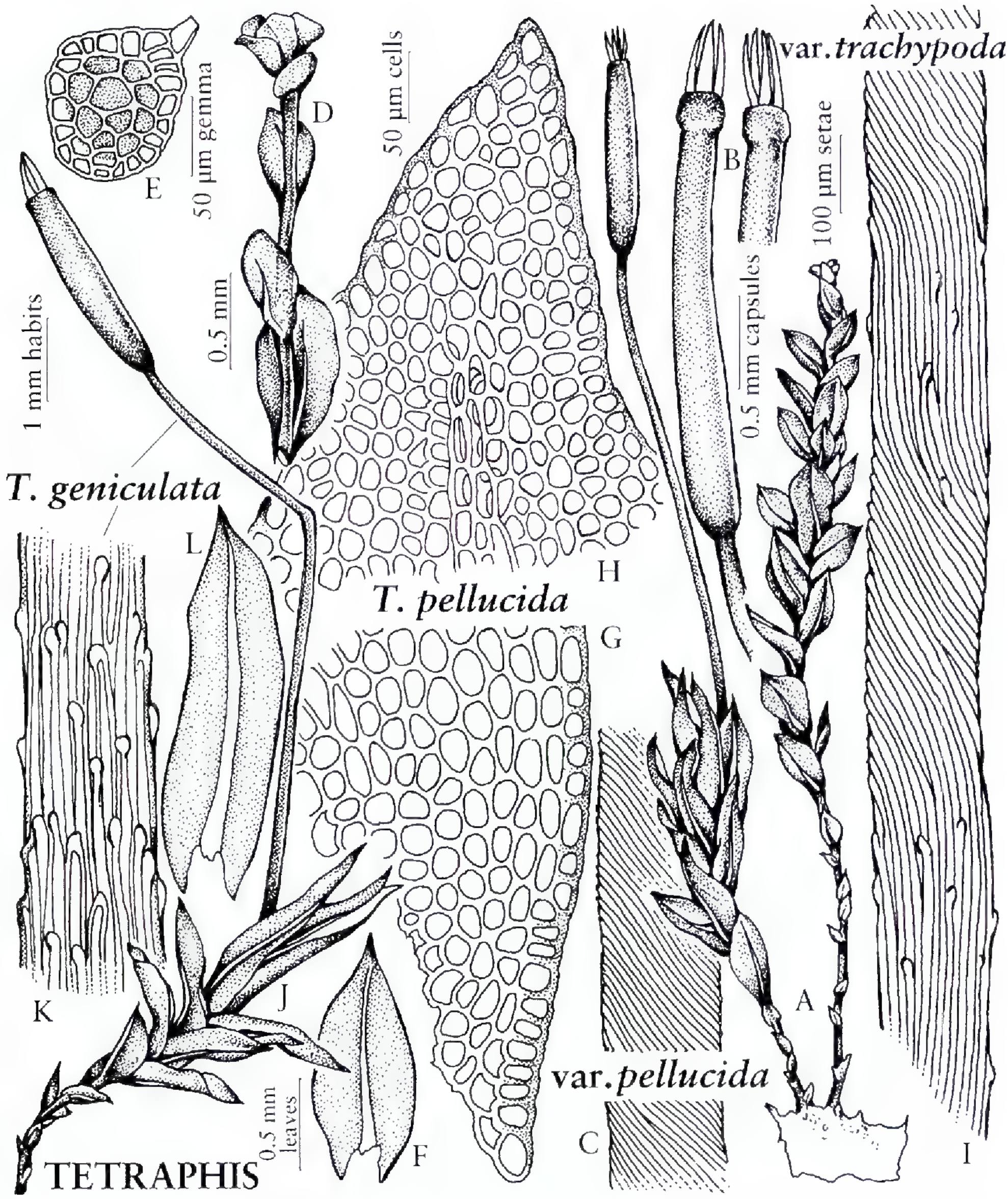


FIG. 2. **A.** habit *T. pellucida* var. *pellucida* and *T. pellucida* var. *trachypoda*. **B.** capsules. **C.** *T. pellucida* var. *pellucida* seta with spirally arranged outer cells. **D.** gemmae cup. **E.** gemma. **F.** leaves. **G.** basal cells. **H.** upper cells. **I.** *T. pellucida* var. *trachypoda* seta with spiral cells interspersed with papillose straight zones. **J.** habit *T. geniculata*. **K.** *T. geniculata* seta with straight papillose cells above the bend. Flora of North America Association, FNA Vol. 27, artist P.M. Eckel.

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of Washington (WTU), and Yellowstone National Park (YELLO). Appreciation is extended to Wilf Schofield for his support during the preparation of this treatment and to Patricia Eckel for her excellent drawing. Barney Lipscomb, Norton Miller and William Weber are thanked for providing helpful suggestions in their reviews of the manuscript.

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A NEW COMBINATION IN THE *BROMUS CATHARTICUS* COMPLEX (POACEAE: BROMEAE SECT. *CERATOCHLOA*)

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ABSTRACT

A new combination, *Bromus catharticus* var. *elata* (E. Desv.) Planchuelo is proposed. This taxon has hitherto been treated either as *B. stamineus* E. Desv. or as *B. cebadilla* Steud. Recent morphological evidence supports its recognition as a variety of *B. catharticus*. Detailed illustrations are included along with a morphological description, synonym list, geographical distribution, and representative specimens.

KEY WORDS: *Bromus*, *Ceratochloa*, Poaceae, Bromeae, South and North America

RESUMEN

Se propone la nueva combinación *Bromus catharticus* var. *elata* (E. Desv.) Planchuelo. Este taxón fue previamente tratado indistintamente como *B. stamineus* E. Desv. o *B. cebadilla* Steud. Evidencias morfológicas recientes validan su ubicación como una variedad de *B. catharticus*. El trabajo se complementa con una detallada ilustración, descripción morfológica, lista de sinónimos, distribución geográfica y especimenes representativos.

During the course of studying materials of *Bromus* deposited in different herbaria, several specimens from AHUC (Holmgren et al. 1990) were sent by the curator for identification. Some of the specimens agree with the morphological features of a native species of *Bromus* from South America which was identified by Cámara Hernández (1978), Matthei (1986), Nicora and Rúgolo de Agrasar (1987), and Zuloaga et al. (1994), as *B. stamineus* E. Desv., and by Gutiérrez and Pensiero (1998), Planchuelo and Peterson (2000), and Pavlick et al. (2003) as *B. cebadilla* Steud. The native area of distribution of this taxon lies primarily in the Southern Andes of the Patagonia region of Argentina and Chile (Gutiérrez & Pensiero 1998). In Chile it grows along the Andes and coastal plains (Matthei 1986), and on Robinson Crusoe Island in the Juan Fernández archipelago (Baeza et al. 2002). In Argentina it grows in western Patagonia (Cámara Hernández 1978) and on the island of Tierra del Fuego (Moore 1983).

This grass was introduced many years ago in Central California for experimental purposes (Hall 1955) and it is now naturalized in North America as reported in Munz and Keck (1959); Wilken and Painter (1993), Kartesz (1994), Pavlick (1995) and Pavlick et al. (2003). Herbarium specimen observations pro-

vide testimony that it is a common garden and orchard weed, growing in disturbed soils in Central and Northern coastal areas of California in the vicinity of San Francisco. Also, there are records of it in northern Oregon and southern Washington (Pavlick 1995). It has also become naturalized in New Zealand (Forde & Edgar 1995), under the names *B. stamineus* and *B. valdivianus*, having been introduced as part of a program of seed sample trials to screen different grasses for their potential forage value.

Phenetic analyses, based on 16 morphological characters, of types and representative specimens of different taxa of sect. *Ceratochloa* (including *B. cebadilla*) (Planchuelo 1991), indicated that *B. cebadilla* and *B. catharticus* should be considered conspecific varieties, as suggested by Peterson and Planchuelo (1998). This variability within this group of grasses has led to the description of numerous taxa at specific and varietal levels based on size, number of nerves, pubescence of the glumes and lemmas, and the length of the lemma awns. Peterson and Planchuelo (1998) clarified the nomenclatural ambiguity of some of the names by accepting the new combination *B. catharticus* var. *rupestris*, leaving the status of other taxa for future investigation. Massa et al. (1997, 2001, 2004)—on the basis of their molecular and morphological studies of 30 germplasm accessions from Patagonia—recommended treating octoploid members of the *B. catharticus* complex as a distinct species, *B. coloratus*, and the hexaploid members as *B. catharticus*. Within *B. catharticus*, they recognized two subspecies, subsp. *catharticus* and subsp. *stamineus*. I compared the morphology and verified the application of the relevant names by examining type materials for members of the *Bromus catharticus* complex. Recognition of *B. stamineus* and *B. cebadilla* at the varietal level seems warranted. At this rank, the epithet *elata*, based on *Bromus unioloides* var. *elata* E. Desv., a taxonomic synonym, has priority. A detailed description, synonyms, representative specimens, geographical distribution and illustrations of *Bromus catharticus* var. *elata* (E. Desv.) Planchuelo are provided below.

Bromus catharticus var. **elata** (E. Desv.) Planchuelo, comb. nov. (**Fig. 1**). BASIONYM: *Bromus unioloides* var. *elata* E. Desv. in Gay, Fl. Chil. 6:438. 1854. *Bromus unioloides* f. *elatus* (E. Desv.) Allen & Thell. ex Kloos, Ned. Kruidk. Archief 1917:164. 1918. TYPE: CHILE: Santiago, *C. Gay s.n.* (LECTOTYPE designated here: K!; ISOLECTOTYPE: P; photo ACOR!, CONC!, SGO). SYNTYPES in text: CHILE: Santiago, *C. Gay s.n.*; Andes de Santa Rosa, *E.F. Poeppig s.n.*; Concepción, *J.S.C.D. d'Urville s.n.*

Bromus cebadilla Steud., Syn. Pl. Glumac. 1:321. Apr 1854. TYPE PROTOLOGUE: CHILE: Rancagua, 1828, *Bertero 117* (LECTOTYPE designated here?: P, fragm. ex P, BAA !; US-865524!; photo SGO, CONC; ISOLECTOTYPE: MO!). SYNTYPES in text: CHILE: Ins. Juan Fernand., *C.G. Bertero 117, 118, 861, 1411* (*Bertero 117* also holotype of *Bromus stamineus* E. Desv.).

Bromus stamineus E. Desv. in Gay Fl. Chil. 6:440. 1854. *Ceratochloa staminea* (E. Desv.) Stace, Watsonia 18:413. 1991. *Bromus catharticus* subsp. *stamineus* (E. Desv.) Massa., Canad. J. Bot. 82 136–144. 2004. TYPE PROTOLOGUE: CHILE: Rancagua, 1829, *C. G. Bertero 117* (HOLOTYPE: P, fragm. ex P, US 865470!; ISOTYPE: MO!; photo, CONC, SGO).

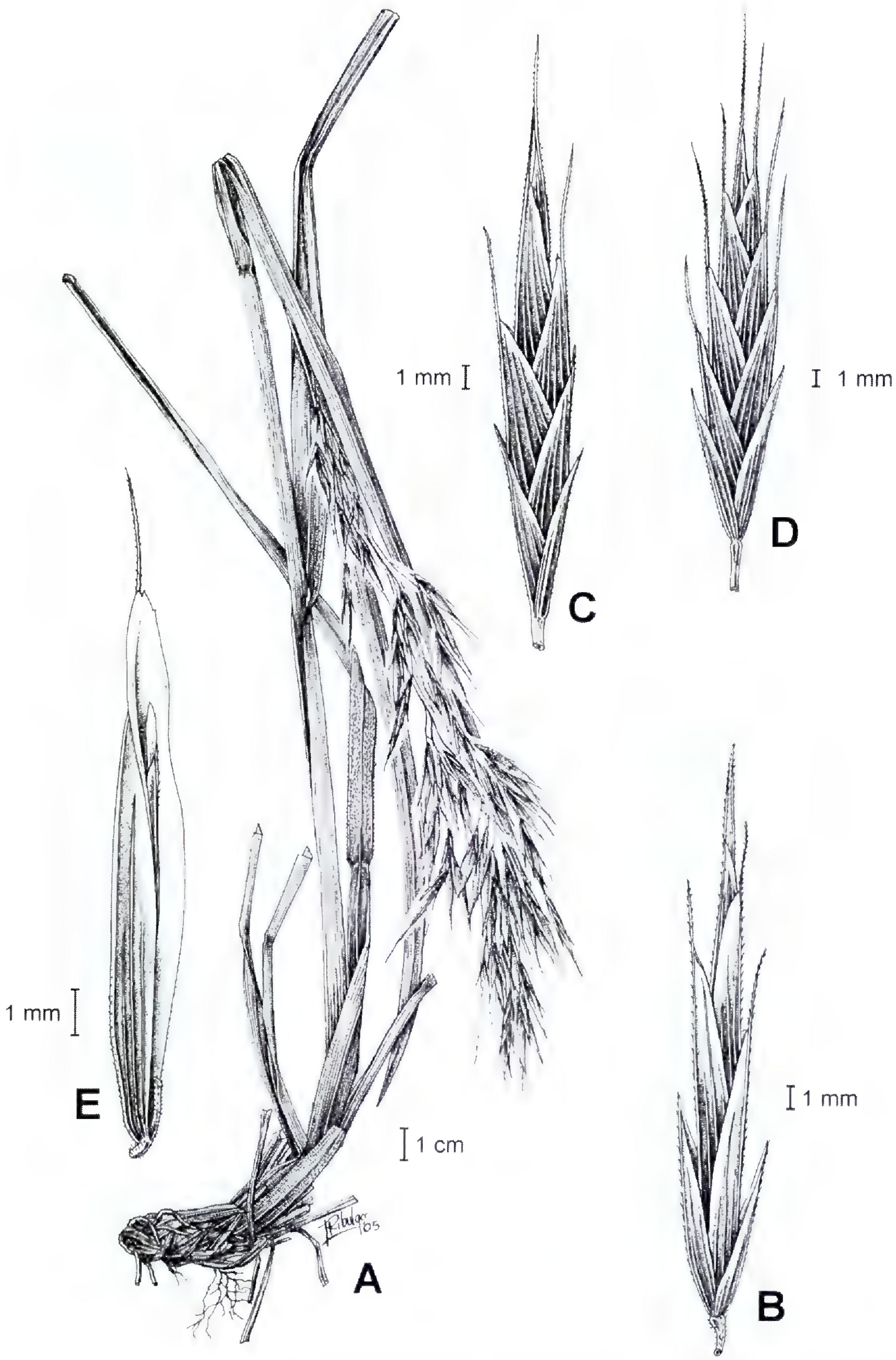


Fig. 1. *Bromus catharticus* var. *elata*. **A.** Habit. **B, C, D.** Spikelets. **E.** Floret. A, B, E, *Illin 73* (CORD); C, *Peñaloza 2220* (AHUC); D, *Howell 29056* (AHUC).

Bromus valdivianus Phil., Linnaea 29:102. 1858. *Ceratochloa valdiviana* (Phil.) Holub., Folia Geobot. Phytotax. 8:171. 1973. TYPE: CHILE. Prov. Valdivia: *R.A. Philippi s.n.* (HOLOTYPE: SGO-PHIL-463).

Usually perennial, occasionally annual, caespitose. Culms 40–100 cm tall, base of the plant with some sheaths from previous seasons. Sheaths glabrous or slightly pubescent open on the upper quarter part. Ligule membranous, glabrous, 2–4 mm long, apex dentate. Auricles absent. Blade 10–30 cm × 4–7 mm, flat, glabrous or slightly pubescent on the upper side. Panicles erect, semi-contracted, 10–20 cm long, with 15–30 or more spikelets, pedicels 2–10 cm long. Spikelets 15–25 mm long, with 4–7-florets, florets imbricate, laterally compressed. Glumes glabrous, the first glume narrowly ovate-lanceolate, 6–8 mm long, 5(–7)-nerved, occasionally only 3 nerves conspicuous, 2 additional nerves evident at the base, the second glume ovate-lanceolate, 7–10 mm long, 7(–9)-nerved. Lemmas ovate-lanceolate, glabrous, usually smooth, occasionally scabrous on all parts, 10–12 mm long, 7–9-nerved, apex bi-denticulate; the awn sub-apical, straight 5–10 mm long. Paleas 10–12 mm long, strongly keeled, with ciliate nerves and adherent to the caryopsis. Anthers 3–4.5 mm long. Caryopsis 7–8 mm long, with a deep, narrow furrow.

Distribution and habitat.—Native to South America, *B. catharticus* var. *elata* grows along the Cordillera de Los Andes from Peru to western Patagonia of Argentina and Chile, and on the islands of Tierra del Fuego and Robinson Crusoe. It is adventive in North America where it occurs in Central and Northern coastal areas of California. Pavlick (1995) reported that it also grows in northern Oregon and southern Washington but no records substantiating his report are known (Barkworth, pers comm. 2006). Reported as naturalized in New Zealand (Forde & Edgar 1995). Grows in disturbed soil, waste places.

Common names.—In Argentina "cebadilla," in Chile: "lanco," "llanco," "cebadilla," "pasto del perro" (Matthei 1986) and in USA "Chilean brome" (Pavlick 1995).

Representative specimens studied. **ARGENTINA. Chubut:** Dpto. Cushamen: Cholila, 15 Jan 1901, *Illins 192* (CORD). **Dpto. Futaleufú:** Lago Futalaufquen, 9 Jan 1948, *Soriano 2868* (BAA); 3 Feb 1955, *Burkart 19781* (SI, US); 5 Feb 1955, *Burkart 19818* (SI, US). **Dpto. Languineo:** Región del río Corcovado, 20 Dec 1901, *Illin 28* (CORD); 71° W 43° S, 4–6 Mar 1901, *Illin 73* (CORD). **Neuquén: Dpto. Lacar:** Parque Nacional Nahuel Huapi, Lago Traful, 7 Nov 1949, *Boelcke et al. 3646* (BAA); San Martín de los Andes, Dec 1938, *Parodi 13212* (BAA). **Río Negro: Dpto. Bariloche:** Lago Nahuel Huapí, 900 msm, 8 Feb 1934, *Parodi 11748* (BAA). **Dpto. Bariloche:** Bariloche, *Parodi 155691/2* (BAA); Cerro Catedral, Dec 1961, *Ellenberg 1059* (BAA). **CHILE. II Región de Antofagasta:** Antofagasta, Quebrada Cerisso, road to airport S of Antofagasta, 27 Feb 1939. *Beetle 26188* (MO, US). **III Región de Atacama:** Atacama, 27 Feb 1939. *Beetle 26188* (MO). **IV Región de Coquimbo:** Dpto. Illapel, Choapa, desvío Pola hasta túnel, 1200–1350 msm, 12 Oct 1945. *Biese 2128* (LIL). **V Región de Valparaíso:** Valparaiso, An Wegen, 1895, *Buchtien s.n.* (US); Zapallar, 1 Feb 1920, *Holway et al. 308* (US). **VII Región del Maule:** Maule, *Arroyo 96089* (CONC, MO). Constitución, Oct 1891 *Philippi s.n.* (US). **VIII Región del Bio Bío: Concepción:** 29 Oct 1919, *Holway et al. 150* (US); Oct 1925. *Claude-Joseph 179* (US). **IX Región de la Araucanía:** Cajón, Dec 1942, *Claude-Joseph 5812* (US); **X Región de los Lagos:** Valdivia, 1888. *Philippi s.n.* (US). **PERU. Junín:** Tarma, 11° 56' S 75° 56' W, 3780 msm, 7 Jan 1983, *Smith 2980* (MO). **La Libertad:** Trujillo, Cerro Cabezón, 500 msm, 4

Nov 1983, *Sagastegui & Lopez 11005* (MO) **UNITED STATES OF AMERICA: CALIFORNIA: Alameda Co.:** Gill Tract Albany, 5 Jun1944, *Stebbins Jr. 436-1* (AHUC); Berkeley, 29 Apr 1916, *Smith s.n, AHUC 2029* (AHUC); 14 May 1942, *Beetle 3267* (AHUC); 27 May 1942, *Harlan 2745* (AHUC); U.C. Campus, Oxford st. opposite University Ave., 3 Jun 1924, *Buckley 14* (AHUC); in front of Helgard near Oxford, 4 May 1923, *Kennedy s.n, AHUC 2027, 2028* (AHUC). **Fresno Co:** Kings River Canyon near Copper Creek, 5000 ft elevation, 2 Aug 1958, *Howell 34232* (AHUC). **Humboldt Co.:** Fortuna, Fair ground's experi mental area, 19 Aug 1947, *Murphy s.n, AHUC 26298* (AHUC). **Mendocino Co.:** Van Damme State Park, Mendocino and ca. 1 mi up Little River from Van Damme Beach, along Fern Canyon trail, 14 Jul 1988, *Bowcutt 1099* (AHUC). **Marin Co.:** Tiburon Blvd., 150 yards E of Blackfield Dr., 26 Aug 1961, *Peñalosa 2220* (AHUC). **Napa Co.:** Oakville, Elev. ca. 160 ft, 20 May 1951, *Raven 2836* (AHUC); Calistoga, altitude ca. 300 ft, 5 May1957, *Raven 10788* (AHUC). **Sacramento Co.:** Brown´s Ranch, Elk Grove, 25 Apr 1947, *Cakin s.n., DAV 10032* (AHUC). **San Luis Obispo Co.:** Adelaide Road, 4.7 mi W of Paso Robles, 1700 ft, 21 May 1960, *Twisselmann 5970* (AHUC). **San Francisco Co.:** San Francisco, Jackson Street, 2 Jun 1953, *Howell 29056* (AHUC). **Sonoma Co.:** Bluffs above the sea, Sonoma Coast State Park, along State Hwy. 1, 0.9 mi N of Salmon Creek, 11 Jul 1957, *Crampton 4326* (AHUC). **Yolo Co.:** UC Davis agronomy experimental area, plant introduction nursery, May 1950, *Crampton s.n. AHUC 042728* (AHUC).

Planchuelo and Peterson (2000) recognized eight species in the South American members of sect. *Ceratochloa*. Massa et al. (2004) proposed recognizing only two species, *B. catharticus* and *B. coloratus*, with two subspecies within *B. catharticus*. In this paper, one of the species recognized by Planchuelo and Peterson (2000) as *B. cebadilla* is reduced to a variety. The status of the other species recognized in the mentioned paper merits further study.

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CHROMOSOME NUMBERS FOR WESTERN AND ARCTIC NORTH AMERICAN SPECIES OF *ANTENNARIA* (ASTERACEAE: GNAPHALIEAE)

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ABSTRACT

Chromosome numbers were determined from somatic material for 73 individuals of *Antennaria* Gaertn. (Asteraceae: Gnaphalieae) representing 10 species from western and arctic North America. These counts support, and represent the typically more frequent, previously reported chromosome number determination for the respective species and as such are presented without comment, though they do supplement our knowledge relative to chromosome number distributions for these species.

RESUMEN

Se contaron los números cromosomáticos en material somático de 73 individuos de *Antennaria* Gaertn. (Asteraceae: Gnaphalieae) que representan a 10 especies del oeste y el ártico de Norte América. Estos recuentos apoyan, y representan el número típicamente más frecuente, previamente citado para la especie respectiva y como tales son presentados sin ningún comentario, aunque complementan nuestro conocimiento relativo a las distribuciones de números cromosomáticos de estas especies.

The purpose of this paper is to supplement the chromosome literature for North American *Antennaria* with previously unpublished data. The methodology employed for chromosome number determination was previously described (Chinnappa & Chmielewski 1987). Voucher specimens remain in the possession of the author and duplicates are deposited in SLRO. The author collected all specimens and staminate specimens are designated with an asterisk (*).

Asteraceae

Antennaria densifolia Porsild. $2n = 28$. **YK:** Dempster Hwy., Engineer Creek, kilometer post 178, 65° 14.243' N and 138° 17.714' W, *Ch3138*, Ch3139*; N of Tombstone Campground, kilometer post 201, 65° 23.900' N and 138° 16.411' W, *Ch3140*, *Ch3141**; approx. kilometer post 213, 65°28'100' N and 138°12.312' W, *Ch3142*, *Ch3143**.

Antennaria friesiana (Trautv.) Ekman ssp. **alaskana** (Malte) Hultén. $2n = 28$. **AK:** Steese Hwy., vicinity of milepost 108, Eagle Summit, 65° 29.515' N and 145° 23.314' W, *Ch3098*, *Ch3099**; 65° 30.367' N and 145° 22.704' W, *Ch3100*, *Ch3101**; Dalton Hwy., Finger Mtn., 66° 21.465' N and 150° 27.694' W, *Ch3108*, *Ch3109**;

Chandler's Shelf, approx. 63 mi N of Coldfoot, 68° 03.026' N and 149° 37.431' W, *Ch3115, Ch3116**; Atigan Pass, 68° 08.225' N and 149° 26.654' W, *Ch3119, Ch3120**.

Antennaria friesiana (Trautv.) Ekman ssp. **friesiana**. $2n = 56$. **AK:** Dalton Hwy, vicinity of Toolik Lake, 68° 38.411' N and 149° 30.815' W, *Ch3118*. **YK:** Top of the World Hwy., Boundary rest area, 64° 04.48' N and 140° 58.598' W. *Ch3132*.

Antennaria howellii Greene. $2n = 84$. **AB:** Yellowhead Hwy., W of Vermillion, 53° 20.188' N and 110° 57.004' W, *Ch3065*; BC: BC 2, E of Pink Mtn., milepost 140, 57° 01.454' N and 122° 26.738' W, *Ch3068*; E of the Yukon border, 59° 57.818' N and 127° 29.890' W, *Ch3073*. **MB:** Hwy 16, E of Neepawa, 50° 13.546' N and 99° 01.443' W, *Ch3053*. **ON:** Trans Canada Hwy., W of Spanish River, 46° 12.289' N and 82° 23.832' W, *Ch3048*; W of White River but E of Marathon, 48° 43.143' N and 85° 42.543' W, *Ch3049*; Kakabeka Falls, 48° 23.762' N and 89° 37.925' W, *Ch3050, Ch3051*. **SK:** Yellowhead Hwy., E of Sheho, 51° 34.483'N and 103° 11.392' W, *Ch3056*.

Antennaria microphylla Rydb. $2n = 28$. **AB:** Yellowhead Hwy, W of Vermillion, 53° 20.188' N and 110° 57.004' W, *Ch3063**, *Ch3064*; **SK:** Yellowhead Hwy., W of Langham, 50° 57.243' N and 102° 03.873' W, *Ch3055*; E of Sheho, 51° 34.483' N and 103° 11.392' W, *Ch3058**, *Ch3059**; W of North Battleford, 53° 03.284' N and 109° 07.845' W, *Ch3061**.

Antennaria monocephala DC. $2n = 28$. **AK:** Richardson Hwy., Thompson Pass, 61° 07.899' N and 145° 44.158' W, *Ch3079, Ch3080**; Denali Hwy., rest area approx. 78 mi E of Cantwell, *Ch3090, Ch3091**.

Antennaria pallida E. Nelson. $2n = 56$. **AK:** AK 3, borough of Mirror Lake, 63° 20.606' N and 149° 05.136' W, *Ch3085*; Denali Hwy, approx. 21 mi E of Cantwell, 63° 20.618' N and 148° 17.304' W, *Ch3086*; approx. 22 mi E of Cantwell, 63° 20.002' N and 148° 16. 166' W, *Ch3088*; Denali Hwy., approx. 49 mi E of Cantwell, 63° 10.201' N and 147° 32.652' W, *Ch3089*; Denali Hwy., rest area approx. 78 mi E of Cantwell, *Ch3092*; Taylor Hwy., approx. 22 mi NE of Teslin Junction, 63° 36.781' N and 142° 21. 103' W, *Ch3130*; **YK:** South Canol Road, approx. milepost 170, 61° 41.794' N and 133° 04.206' W, *Ch3147*.

Antennaria parvifolia Nutt. $2n = 112$. **AB:** Yellowhead Hwy., W of Vermillion, 53° 20.188' N and 110° 57.004' W, *Ch3062*. **SK:** Yellowhead Hwy., W of Langham, 50° 57.243' N and 102° 03.873' W, *Ch3054*; E of Sheho, 51-34-483°N and 103° 11.392' W, *Ch3057*; W of North Battleford, 53° 03.284' N and 109° 07.845' W, *Ch3060*.

Antennaria pulcherrima (Hook.) Greene. $2n = 56$. **AK:** Dalton Hwy., Coldfoot, 67° 15.047' N and 150° 10.580' W, *Ch3110, Ch3111**. **BC:** Alaska Hwy., Muncho Lake, 59° 09.577' N and 125° 53.319' W, *Ch3070*.

Antennaria rosea Greene. $2n = 56$. **AB:** AB 43, W of Grande Prairie, 55° 10.240' N

and 119° 16.162' W, *Ch3066*. **AK:** Hwy 1, W of Glenallan, 62° 05.729' N and 146° 14.938' W, *Ch3082*; Seward Hwy., Turnagin Arm, S of Anchorage, 61° 00.387' N and 149° 41.577' W, *Ch3083*; Fairbanks, intersection of Boat St. and Sportsman Way, 64° 50.228' N and 147° 49.445' W, *Ch3096*; Elliott Hwy., S of Livengood, 65° 09.350' N and 147° 53.893' W, *Ch3104*; Dalton Hwy., Yukon River, 65° 52.764' N and 149° 42.890' W, *Ch3105*; N of Yukon River, 65° 57.88' N and 149° 58.931' W, *Ch3106*; Richardson Hwy., North Pole, 64° 45.031' N and 147° 19.524' W, *Ch3124*; Taylor Spur to Boundary, 64° 04.684' N and 141° 06.512' W, *Ch3131*. **BC:** Alaska Hwy., Muncho Lake, 59° 09.577' N and 125° 53.319' W, *Ch3069*; N of Fireside, 59° 41.772' N and 127° 12.992' W, *Ch3071*; E of the Yukon border, 59° 57.818' N and 127° 29.890' W, *Ch3072*. **YK:** Alaska Hwy., Watson Lake, 60° 01.172' N and 128° 34.772' W, *Ch3074*, *Ch3075*; N of Dawson Peaks, 60° 26.671' N and 133° 36.476' W, *Ch3076*, *Ch3077*; Top of the World Hwy., W of 60 Mile Rd., W of kp 86, E of Boundary, 64° 06.929' N and 140° 43.409' W, *Ch3133*; Dawson Bonanza Creek, gold panning site 6, *Ch3134*; Dawson, dome overview, *Ch3135*; South Canol Road, Quiet Lake, 60° 59.475' N and 133° 01.678' W, *Ch3148*; Whitehorse, Miles Canyon, 60° 39.681' N and 135° 01.750' W, *Ch3151*, *Ch3152*.

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Book Review

Londa Schiebinger and Claudia Swan (eds). 2005. **Colonial Botany: Science, Commerce, and Politics in the Early Modern World.** (ISBN 0812238273, hbk.). University of Pennsylvania Press, Philadelphia 19104-4011, U.S.A.. (**Orders:** Hopkins Fulfillment Services, P.O. Box 50370, Baltimore, MD 21211-4370, U.S.A., Tel: 410-516-6956; Fax 410-516-6998. e-mail: hfscustserv@mail.press.jhu.edu). [Price not given.] 346 pp. b/w illustrations, 16 cm × 25 cm.

This book might have been titled the "botanical exploitation of the world" as the great powers, Spain and Holland especially, sent off explorers as much for botanical resources as for the conquest of land. Their quest was, of course, for the spices and condiments that they were buying from the Far East and for the *materia medica* that had long been an integral part of botanical pursuit. Botanical knowledge of the "new" areas was limited; the codification of plants was imperfect, faulty, and often misleading; the understanding of biogeography was rampant with misconceptions. The expeditions were economically and politically motivated with the result of some extreme inhumane practices (such as the atrocities in Banda), and because of ignorance and arrogance the indigenous people's use of plants for medical purposes was often ignored.

The sixteen chapters of this book by as many historians and geographers present particulars of botanical exploration, aspects of colonial history seldom described. Along the way, one may become reacquainted with such botanist-physician explorers as Charles-Marie de La Condamine, Joseph de Jussieu, Carlos Clusius and meet fascinating characters like Nicolás Monardes, who never left Spain, and Daniel Gottlieb Messerschmidt. Facts such as the cultivation of African rice (*Oryza glaberrima*) brought into South and North Carolina by slaves give a new outlook on agriculture and life in the southern colonies.

For this reviewer more botanical identifications would have been welcomed, though some authors are careful to provide them. For instance, what was the "tea" that José Mutis proposed as a substitute for Asian tea? What was the "bastard nutmeg" that Pierre Poivre brought from the Philippines to cultivate in France? Answers to these and other such questions would surely be found in the extensive citations of original and secondary sources for each chapter in the appended Notes.

The editors have assembled an admirable collection of essays that more than adequately explain the motivations and practices with reference to botany during the colonial period.—*Joann Karges (retired TCU Library), Botanical Research Institute of Texas, Fort Worth, TX 76102-4060, U.S.A.*

ROOT-SHOOT ANATOMY AND POST-HARVEST VEGETATIVE CLONAL DEVELOPMENT IN *LOPHOPHORA WILLIAMSII* (CACTACEAE: CACTEAE): IMPLICATIONS FOR CONSERVATION

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ABSTRACT

Over the last four decades, the size and density of populations of *Lophophora williamsii* (peyote) have diminished markedly in large areas of South Texas where licensed peyote distributors harvest the cactus for ceremonial use by the Native American Church. Part of the problem lies in the fact that some harvesters are cutting plants too low on the subterranean stem or taproot. That practice precludes the regeneration of new stems and ultimately results in the death of the decapitated plants. To address this problem, we describe the anatomical distinctions between subterranean stem and root in *L. williamsii* as follows: The stem cortex can be distinguished by the cortical bundles running through the parenchyma, in contrast to the root cortex, which consists of pure parenchyma without cortical bundles. The pith at the center of the stem is pure parenchyma (without xylem) and is readily distinguished from the dilatated metaxylem (with masses of dark-staining metaxylem tracheary elements) occupying the center of the root. With these new anatomical tools, it is now possible to set up titration experiments, first in the greenhouse and then in the field, to generate practical biometric data to determine the maximum depth at which the peyote harvesters can cut the plants without significantly reducing the survival rate of the rootstocks left in the ground after harvest.

RESUMEN

Durante las últimas cuatro décadas, el tamaño y densidad de las poblaciones de *Lophophora wiilliamsii* (peyote) han disminuido drásticamente en grandes extensiones del sur de Texas donde se dan permisos a distribuidores de peyote para recolectar especimenes de uso en las ceremonias religiosas de la Native American Church. Parte del problema estriba en el hecho de que algunos colectores están cortando plantas muy abajo, o en el tallo subterráneo o en la raíz pivotante. Esta práctica impide la regeneración de nuevos tallos y finalmente ocasiona la muerte de las plantas decapitadas. Para abordar este problema, nosotros describimos las características anatómicas que distinguen el tallo subterráneo y la raíz de *L. williamsii* como sigue: El tejido cortical del tallo se distingue por la presencia de haces corticales que se distribuyen por el parénquima, atributo que contrasta con el tejido cortical de la raíz, el cual consiste en puro parénquima sin haces corticales. En el centro del tallo la médula es puro parénquima (sin xilema), y se reconoce claramente del metaxilema dilatado (parches de elementos traqueales del metaxilema teñidos de oscuro) que ocupa el centro de la raíz. En base a estas características anatómicas será posible hacer experimentos de corte, primero en invernadero y después en el campo, con la finalidad de generar datos que permitan determinar la profundidad máxima a la cual los recolectores de peyote pueden cortar las plantas sin reducir significativamente la supervivencia de los individuos que quedan en el suelo después de la colecta.

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INTRODUCTION

Peyote harvest as a conservation problem

Lophophora williamsii (Lem. ex Salm-Dyck) J.M. Coult. 1894, commonly called peyote, is a small, napiform, spineless cactus native to the Chihuahuan Desert and the Tamaulipecan Thornscrub of northeastern Mexico and adjacent Texas. While the mescaline-containing stems are ingested in various forms for their psychotropic effects, this behavior was generally proscribed by federal drug legislation in 1970. However, federal law provides protection for the use of peyote for bona fide religious ceremonial purposes by members of the Native American Church. The supply of peyote for such purposes is regulated by the Drug Enforcement Administration and the Texas Department of Public Safety. The regulated commerce in peyote begins with the harvest of peyote from wild populations by licensed peyote distributors or their agents. Commercial quantities of peyote occur in the U.S. only in Starr, Zapata, Webb and Jim Hogg Counties in South Texas, within 70 km of the Rio Grande, and all four currently licensed peyote distributors are based where peyote grows in those counties. Historically the peyote distributors have gained access to harvestable populations of peyote through peyote-specific lease agreements with private landowners. Most of the actual harvesting of peyote is done by contract laborers who are paid in accordance with the number and size of freshly cut "buttons" (tops of stems) of peyote that they deliver to the licensed distributors.

There has been a decrease in the number, size, extent and density of peyote populations in South Texas (Anderson 1995; Moreno 2005) over the past four decades. Much of this reduction in peyote numbers can be attributed to habitat destruction associated with urban development and agricultural practices such as rootplowing of native brush, and some adverse effects on population numbers may have been due to illicit harvesting. Such phenomena are difficult to quantify and virtually impossible to prevent. One factor that *is* quantifiable in the decline of peyote in South Texas is the regulated commercial harvest of peyote by the licensed distributors for ceremonial use by the Native American Church. Approximately two million peyote buttons per year have been harvested by these distributors over the last two decades (Texas Department of Public Safety, unpublished data). And the technique used in the harvest of those plants could logically have a substantial impact on the observed decline—or the potential recovery—of peyote populations in the Tamaulipecan Thornscrub of South Texas.

The proper technique for harvesting peyote is that the crown (i.e., the aerial, photosynthetic portion of the stem) of the peyote cactus is cut off at or immediately below its base, and the subterranean portion of the plant, including all or most of the subterranean portion of the stem, is left in the ground to regenerate one or more new crowns. Such harvesting of the commercially valuable crown of the cactus may be accomplished by cutting through the plant trans-

versely at the level of the surface of the ground, at or near the interface of the green crown and the brown subterranean portion of the stem, using a machete, a cutting tool with a broad flat blade and a handle about 60 cm long (such as a hand edger), or virtually any kind of knife (M. Terry, pers. obs., Fig. 1a–c).

When proper harvesting technique is adhered to, the decapitated subterranean portion of the stem and the more distal taproot of the cactus (Fig. 2) remain intact and *in situ*, where the viable subterranean stem tissue will normally begin to regenerate one or more new crowns by lateral branching from axillary (areolar) buds within a few months after loss of the apical meristem (Fig. 3). Such regenerated crowns may in turn be sustainably harvested after they reach maturity, some years later (Fig. 4).

Peyote harvest—degeneration and death of the decapitated plant

Not every peyote plant responds in the same manner to removal of its apical meristem along with the crown at harvest. The simplest response is that described above: regeneration of one or more new crowns by lateral branching from (usually subterranean) stem tissue (Fig. 3). But frequently we observe a more complex, gradual response, which begins with simple lateral branching from the remaining stem of the decapitated plant. The difference is that the new stem branches, instead of remaining dependent on the taproot of the original plant, put down their own adventitious taproots and eventually become independent plants that detach themselves from the original plant, which—if its crown was completely removed at harvest—degenerates and dies in this process.

The unusual aspect of this second type of response of peyote to removal of its apical meristem in the harvesting process, is that the regeneration of new stems and the generation of new adventitious taproots from the new stem branches proceed in a seamless developmental process until at some point it must be recognized that the new, increasingly autonomous shoot-root units have become independent vegetative clones of the original plant. That is to say, where we started with a single decapitated plant undergoing development of new stem branches, we end up with what must be recognized as a moribund *parent* plant with viable clonal *progeny*.

Another remarkable feature of this process is that as the clonal progeny become larger and more nutritionally independent, the stem tissue connection between the parent plant and each of the vegetative clones degenerates to a slender tube consisting mostly of vascular tissue, while the parent plant (which has no photosynthetic capabilities of its own) steadily decreases in size and density as the nutrients stored in its parenchymal tissues are depleted and utilized by the growing clonal offspring. In the final phase of the process, the connection between the parent plant and the now nutritionally independent progeny disintegrates, and what is left of the decapitated parent plant dies. This series of events is depicted in Figures 5–12. All the photos in these figures are of



FIG. 1a. Proper peyote harvesting technique. Plant is cut transversely at base of crown, i.e., at ground level.

specimens that the first author collected from populations near Rio Grande City, Starr County, Texas.

This natural process of vegetative clone production in response to the excision of the apical meristem that occurs when peyote crowns are harvested, is remarkably congruent with the folk belief that harvesting peyote results in an increase in the number of plants in a population, and that where one plant grew before harvesting, several plants may be found after allowing an adequate period of time for the peyote to "grow back." A necessary condition for this process to occur, however, is that the harvesting be done in a manner that does not preclude the production of new stems from the subterranean stem of a plant from which the crown has been harvested. What does this mean in terms that could serve as a practical guideline for sustainable harvesting?

The answer must be based on an understanding of the anatomy of the root and stem of *Lophophora williamsii*. We begin with the observation that of all the people working with this plant—and here we include peyote distributors, members of the Native American Church, cactus hobbyists in countries where peyote cultivation is legal, and even botanists—very few appreciate the distinction between true root and subterranean stem. Yet this distinction is crucial to



FIG. 1b Proper peyote harvesting technique. Cut has been made parallel to ground surface, and harvested crown (below, about 5 cm in diameter, with 8 ribs) has been removed from subterranean portion of stem (above, remaining in the ground). Cut surface shows cross section of vascular cylinder (ring of yellow tissue near center of stem), pith within the vascular cylinder, and yellowish green parenchymal tissue of the cortex of the stem (between vascular ring and epidermis).

an understanding of how to harvest peyote so that it will "grow back," because, as far as we have been able to determine from observations to date, new stem branches will develop only from stem tissue, not from root tissue. Therefore, if in harvesting the crown one cuts so deeply below the crown that all or most of the subterranean stem tissue is removed along with the crown, then there will be no possibility of new stem development, and the stemless root left in the ground will simply perish. With that as the operating premise, let us now consider the anatomy of the root and the shoot of *L. williamsii*, and how to distinguish between them.

Ideally we should like to be able to identify the shoot-root transition zone in order that at least some portion of the shoot should remain with the root of the plant left in the ground after harvest. Unfortunately, the plants normally protrude only 1–3 cm above the surface of the ground and have a large subterranean shoot that tapers gradually until it ends in a taproot. The shoot-root transition zone does not occur near the soil level where the seed germinated



Fig. 1c. Proper peyote harvesting technique. Underside of harvested crown (left) shows very narrow (2–3 mm wide) ring of bark at perimeter of cut surface, indicating that the cut was barely below base of crown, in uppermost portion of subterranean stem. Cut surfaces match, except that crown parenchyma (left) is slightly greener due to higher chlorophyll content, whereas subterranean stem parenchyma (right) is more yellowish.

but instead occurs at various depths (higher in smaller plants, lower in larger plants). It is not possible to identify the shoot/root transition zone merely by examining an intact plant with the naked eye.

In most seed plants, young shoots and roots can be distinguished from each other because the shoot has a pith and cortex whereas the root lacks both these structures (Mauseth 1988). However, several other cacti grow like peyote—having a large below-ground shoot that tapers into a large taproot—and the shoot-root nature of those structures has not been clarified (Stone-Palmquist & Mauseth 2002). Early workers on the anatomy of *Lophophora* (Rouhier 1927; Bravo 1931; Janot & Bernier 1933) gave fair to very good anatomical descriptions of root and shoot, but even Bravo, whose description of the subterranean stem and root of *Lophophora* was the best available in its day, admitted that "[it is most difficult to know in which region the stem ends and in which the root begins]..." (Bravo 1931, translated from the Spanish). Because better harvest techniques may aid the survival of this species in areas subject to intensive harvesting for human consumption, as in South Texas, we undertook a histologic study of the anatomy of roots



FIG. 2. Peyote plant immediately after most of crown has been harvested, showing cut just above base of harvested crown (green tissue at top), subterranean stem (brown bark-covered tissue immediately below cut base of crown) capable of regenerating new crown(s), and tapering taproot (bottom part of plant with a few visible lateral roots).

and shoots in *L. williamsii* to determine if there are reliable criteria for distinguishing the root from the shoot (and particularly the subterranean portion of the shoot). We especially looked for criteria that could be used in the field.

MATERIALS AND METHODS

Plants were collected by M. Terry (DEA Researchers Registration No. RT0269591) from a wild population of *L. williamsii* near Rio Grande City in Starr County, Texas, or, in the case of one specimen (the very large plant), donated for research purposes by law enforcement personnel. Specimens examined included two very small plants, two plants of intermediate size and one very large plant (Table 1).

TABLE 1. Dimensions of the three adult plants studied, listed from shortest to longest. All values are in millimeters. Shoots of plants #1212 and #1213 were sampled at ground level and at two below ground levels; shoot of plant #1214 was sampled at only one below-ground level. The root of each plant was sampled only at the top of the root, where it most resembled a portion of shoot.

Sample	Plant length	Aerial height	Plant diam. at soil level	Shoot cortex thickness	Shoot pith diam.	Root cortex-like zone thickness	Root pith-like region diam.
Plant 1212, at ground level	135	24	55	20	4		
1212, at -20 mm				13	6		
1212, at -25 mm				9	6		
1212, root, -35 mm						1.5	10
Plant 1214, at ground level	140	44	78	32	10		
1214, at -35 mm				6	2		
1214, root, -41mm						3.0	27
Plant 1213, at ground level	160	40	59	14	6		
1213, at -20 mm				14	6		
1213, at -35 mm				9	8		
1213, root, -45 mm						1.0	3.4

Plants were dissected with care being taken to obtain samples of material that was definitely root (provisionally defined as the region below the uppermost point at which a lateral root had emerged), definitely shoot (namely the aerial portion of the shoot—specifically known as the crown, *sensu* Schultes (1938)—which has a blue-gray to blue-green epidermis, photosynthetic tissue and axillary buds), and definitely hypocotyl (the transition zone between shoot and root) samples being obtained by taking numerous samples between obvious root and obvious shoot). In all but the smallest, youngest plants, the plant material that was easily recognizable as root was located at least 35 mm below soil level (45 mm below in plant #1213; Table 1). Since the nature of the higher subterranean portions of *L. williamsii* was in question, samples were taken from all plants examined, with the position of each sample being carefully measured with the soil level (taken as the level of the base of the crown) as reference.

As tissue samples were obtained during dissection, they were immediately immersed in Navashin's solution, then aspirated in a vacuum chamber to remove air and permit rapid penetration of fixative. Tissues were fixed for 24 hours, dehydrated through mixtures of ethanol and tertiary butanol, then embedded in Paraplast Plus. After microtoming, sections were stained with Safranin and Fast Green by a procedure designed especially for cacti (Mauseth et al. 1985).



FIG. 3. Two young peyote crowns ("pups") regenerating by lateral branching from the upper edge of the subterranean stem of a plant that was decapitated 7.5 months previously. This plant is the same individual shown in Figs. 1a–1c. Each of the new crowns is ca. 1.5 cm in diameter

RESULTS

Morphology

All plants tapered gradually from an unbranched aerial shoot to a region of subterranean shoot, then to hypocotyl, and finally to taproot. The taper was uniform in most plants, without any abrupt change in diameter that might indicate the boundary between shoot and hypocotyl or between hypocotyl and root. The two smallest plants that we examined (whose above-ground, photosynthetic crowns were 15 mm in diameter) were only 31mm long (9 mm above ground, 22 mm below ground) and 50 mm long (10 mm above ground), so seeds must have germinated at or slightly below ground level. However, in the three adults we examined, the root/shoot junction was located at least 35 mm below the soil level (45 mm below in plant #1213), so plants of *Lophophora williamsii* must have contractile roots pulling the root/shoot junction deeper as the plant ages. All above-ground portions of shoot were covered with a blue epidermis; all subterranean portions were covered with thin, flaking brown bark. Ribs and axillary buds (often called areoles in cacti) were obvious on all above-ground portions, and withered areoles were occasionally detected (as much as 17 mm below soil level on plant #1213).

Slender lateral roots (1–3 mm diameter) emerged from taproots, but were extremely sparse, with only two or three present on any plant. This could be in



FIG. 4. Repeated harvesting of successive crowns from the same peyote plant. Individual on left bears notches (see arrows) indicating stem regeneration after having its crown harvested three times in the past. Individual on right has never had its crown harvested (the distal end of the root broke off when the plant was dug up for examination).

part because most lateral roots in this species are ephemeral (emerging in response to moisture, then being shed in conditions of drought), small, and fragile (M. Terry, pers. obs.). The result is that all but the few largest lateral roots are broken off and left in the ground when one uproots the plant from its natural growth site in habitat—no matter how carefully one goes about extracting the plant. When one grows the plant in loose, friable soil under artificial conditions, more lateral roots and their finer branches remain intact when the plant is depotted. The plants used in this study, however, were recently uprooted from



FIG. 5. This is a normal peyote plant with a single long lateral root and no obvious evidence of previous harvesting. The symmetry of the annular constrictions on the long subterranean stem suggests reduced growth rates in periods of winter and/or drought. The crown of this mature plant measures ca. 6 cm in diameter and has eight ribs. The shallow, elongated indentation in the side of the crown facing the reader is a scar from tissue sampling for DNA analysis 18 months previously.

the gravelly soil of their habitat and this would account for some reduction in the number of intact (and therefore observed) lateral roots.

Lateral roots emerged only from areas that were later shown to be taproot or hypocotyl, not from shoot tissue. But one plant examined in the field but not dissected and studied here had a root emerging from its side at about the same level as a lateral stem branch; that root might have emerged from the hypocotyl rather than the shoot but that is not known. This isolated field observa-



FIG. 6. This is a good example of a plant that was decapitated exactly once, several years ago, judging from the size of the new crown (ca. 5 cm diameter). Note that the crown-bearing lateral branch is markedly offset from the center of the original subterranean stem seen at the base of the lateral branch. That is a consequence of the fact that the lateral branch originated from an areole on the side of the subterranean stem.



FIG. 7. This plant shows evidence of having been previously harvested at least twice. The small sizes of the two crowns on lateral branches from the original subterranean stem suggest that the most recent harvesting of this plant was perhaps 2–4 years ago. (The larger of the two crowns is about 2.5 cm in diameter. Both are 5-ribbed.)

tion should be interpreted in light of the possibility that some of what appear to be uppermost lateral roots of *Lophophora* may prove to be adventitious roots emerging from subterranean stem tissue. Whether ordinary subterranean stem tissue can produce adventitious roots, or whether adventitious roots can be produced only by regenerative lateral branches from a plant whose apical meristem has been removed, is an anatomical issue still to be resolved.



FIG. 8. This plant has been harvested several times. Only one of the two new crowns is visible from this view, but the two adventitious taproots, each originating in a stem branch bearing a crown, are both visible (protruding to lower right). Each of the two crown-bearing stems has recently developed by lateral budding from a *previous* harvest-associated lateral branch that was itself decapitated near ground level. The two new crowns, each with its own adventitious taproot, are well on their way to becoming independent of the parent rootstock. The original/parental plant, represented by its bark-covered taproot protruding to lower left from the original subterranean stem (also bark-covered), is degenerating, but its subterranean stem is still alive and still attached to the subterranean stems of the two clonal progeny.



FIG. 9. Two vegetative clones that originated as lateral branches of the stem of a decapitated parent plant, which is degenerating but still clearly recognizable as the bark-covered subterranean stem with taproot extending down between and beyond the taproots of the two new plants. There is still a connection (not shown directly, but inferable from the inter-adherence of the plants in the photo) between the new plants and the parental plant, but each of the young plants has its own functional taproot and is virtually independent of the parental rootstock by now. Visible damage to the crowns is attributed to the activity of natural herbivores, probably terrestrial snails, which are known to consume *L. williamsii* crown tissue.



FIG. 10. This pair of "sister" vegetative clones is different from that shown in Fig. 9, in that the lateral branch on the left has effectively co-opted the taproot of the parent rootstock as its own taproot, whereas the lateral branch on the right has developed an adventitious taproot of its own, which will lead to its eventual separation from the parent rootstock.

Several plants had shrunken, withered tubercles on their subterranean portions. They were wrinkled and covered with bark just like all other subterranean portions, but their centers contained living parenchyma cells and an apical meristem, apparently the shoot apical meristem of the tubercle. The lowest one found on each adult plant was 15 mm below soil level on plant #1212, 30 mm on plant #1213, and 22 mm on plant #1214.

Withered tubercles were identifiable on subterranean, bark-covered por-



Fig. 11. Three clonal sister peyote plants—each anatomically and functionally on its way to independence with its individual crown and taproot—still attached to the parental subterranean stem (visible as the dark brown structure between the taproots of the middle and right clonal sister plants).

tions of two of the adult plants. Tubercles were reliably identifiable only in the uppermost 4.0 mm of subterranean shoot; below that, they had withered so much that the only visible remnants were peg-like structures 2.0–3.0 mm in diameter and 1.0–2.0 mm tall, which appeared to be deteriorated areolar tufts of trichomes. Bark was sufficiently wrinkled and rough that some of its irregularities resembled withered tubercles, making identification of tubercles difficult. Subterranean withered tubercles should have been aligned with the rows of tubercles on the aerial portions (Fig. 13), but there were only two cases in



FIG. 12.The amorphous, decaying mass (right) that is tenuously attached to the subterranean stem of the live cactus (left), is the dead remnant of the subterranean stem of a parent plant that was decapitated by peyoteros sometime in the past. The young specimen that developed from the then-living parental subterranean stem, is now fully formed, with its own taproot, and is fully independent. The very low density of the attached mass suggests that it is in an advanced stage of decomposition.

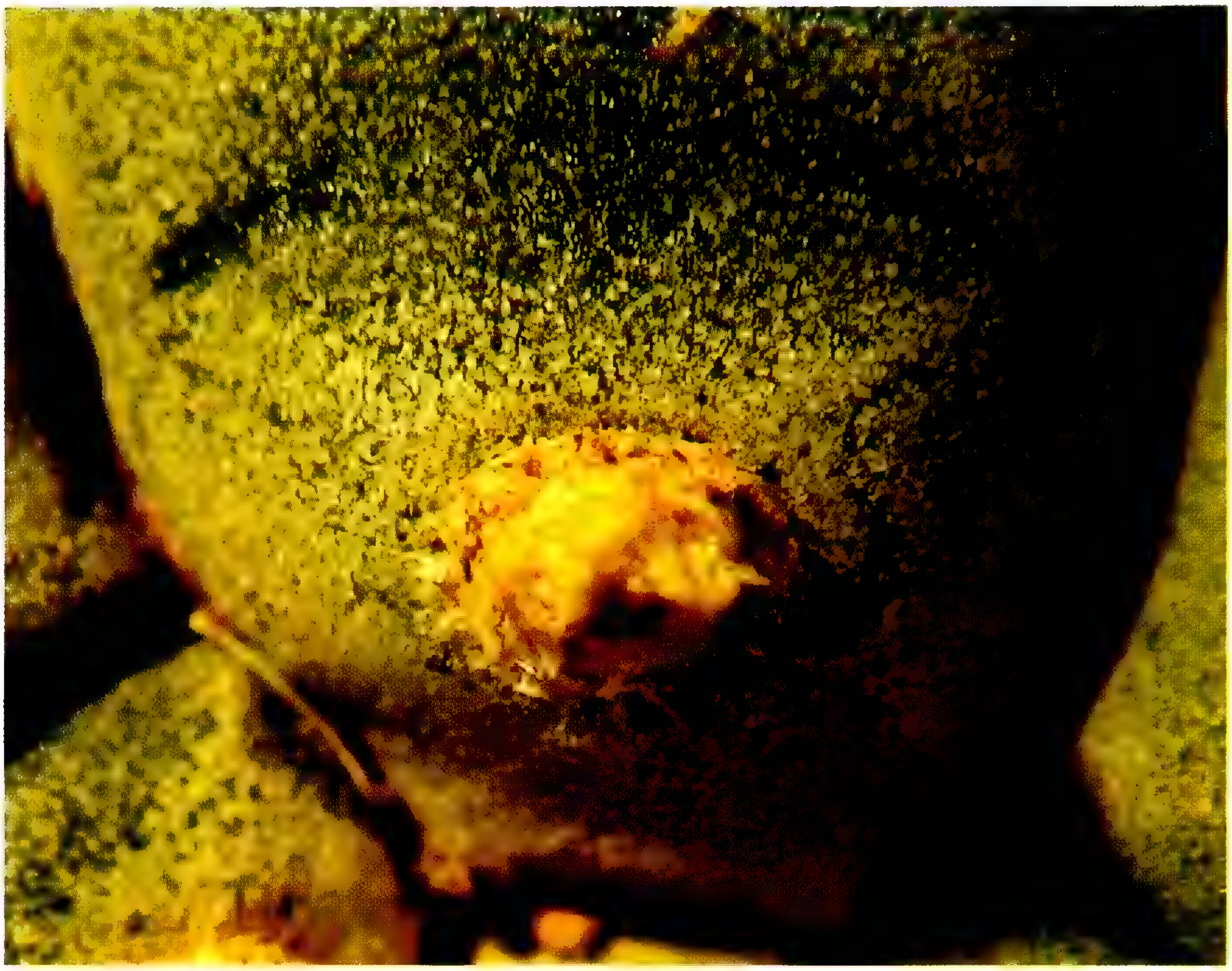


FIG. 13. *L. williamsii* young tubercle with areole bearing woolly trichomes. The apical meristem from which the areoles emerge radially is immediately below the field of the photograph.

which a row of withered tubercles could be identified by their areolar tufts (Fig. 14). We followed rows of tubercles from the aerial portions of shoots down into subterranean portions but usually could not find any identifiable withered tubercles, apparently the areolar tufts abscise from the plant.

Structure of the root

Very young regions of root (less than 0.5 mm in diameter) had an organization typical of most dicots. There was an epidermis, a thin cortex only a few cells thick, endodermis and vascular tissue consisting of small bundles of primary phloem alternating with arms of protoxylem, and metaxylem occupied the very center. An important point is that metaxylem contained significant amounts of living xylem parenchyma cells, it did not consist entirely of dead tracheary elements. This organization was found in only the two smallest, youngest plants, in samples taken from closest to root tips. Older portions of roots (2.5 to 30 mm in diameter) had altered their organization. They had lost their epidermis and cortex, and parenchyma cells in the metaxylem had begun to proliferate. Sec-

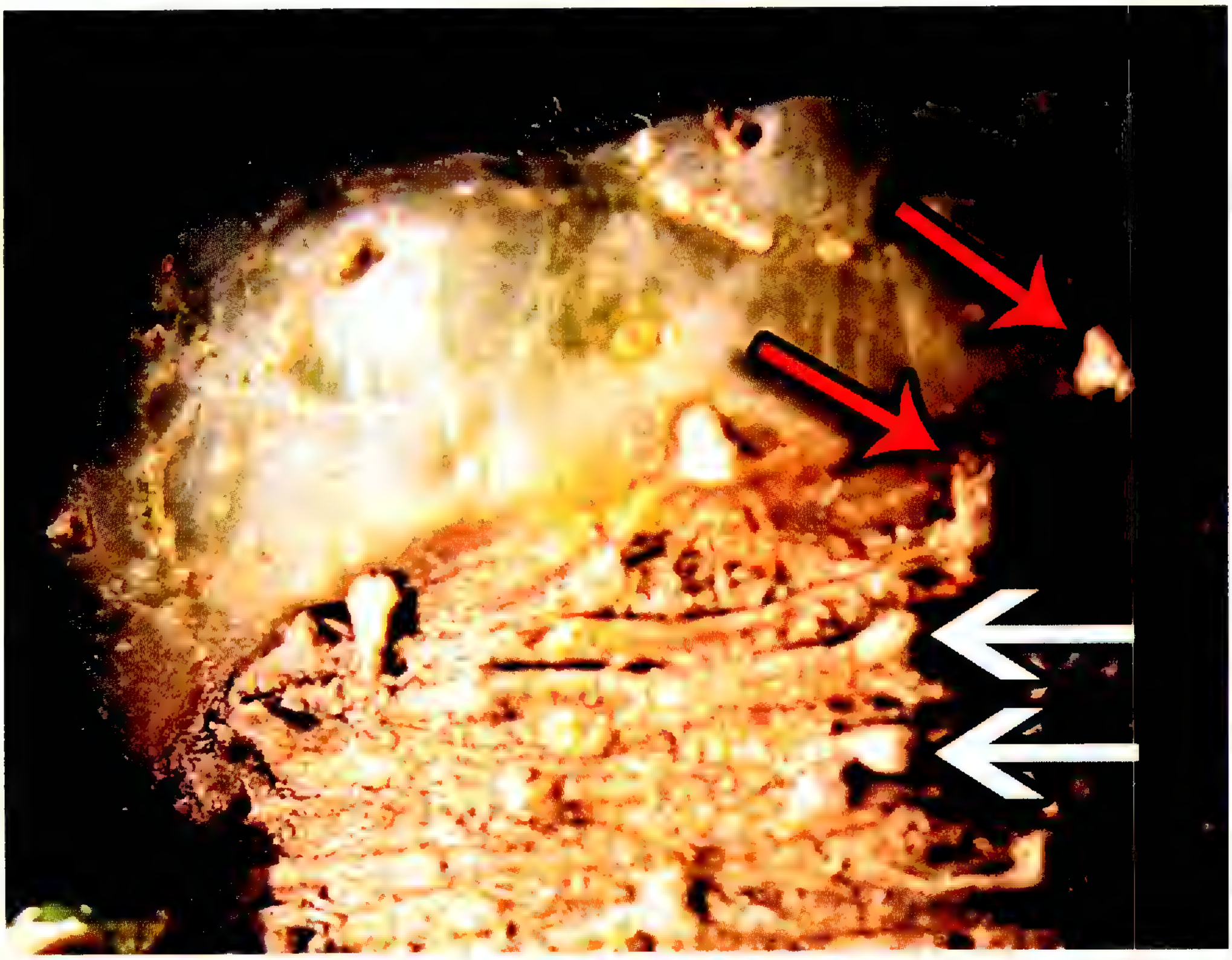


FIG. 14. *L. williamsii* tubercles with tufted areoles (red arrows) on lower portion of crown (green tissue in upper half of photo). On the corrugated brown surface of the subterranean stem (lower half of photo) in the transition between light and shadow are two lighter-colored protuberances, situated on a diagonal curve containing the two tufted areoles above in the crown. These protuberances (white arrows) are the visible areolar remnants of stem tubercles, which are the source of lateral branches of stem that develop in response to removal of the apical meristem.

ondary xylem (wood) and phloem were present, but epidermis, cortex and endodermis had been replaced by a bark consisting of thin flakes of cork. Just interior to the bark was a band of parenchyma that appeared to be cortex but which was really secondary phloem parenchyma. This cortex-like region was about 0.3 to 3.0 mm thick and extended inward from the bark almost to the vascular cambium. Thickness was correlated with root size: roots less than 4.0 mm in diameter had a cortex-like region only about 0.3 to 0.4 mm thick; roots about 10–12 mm in diameter had a cortex-like region 1.0 mm thick; and very large roots 30 mm in diameter had a cortex-like region 3.0 mm thick. The cortex-like region was recognizable as secondary phloem only because it had traces of collapsed sieve tube members in it. There were no vascular bundles in the cortex-like region other than very rare connections with lateral roots, and these were oriented vertically rather than radially or tangentially.

Metaxylem parenchyma proliferated in roots, producing such abundant amounts of parenchyma that the center of the root appeared to have a pith. Metaxylem vessel elements were pushed apart (such proliferation in an otherwise mature tissue is called dilatation), and parenchyma cells in the innermost, first-formed wood also underwent dilatation growth. This pith-like region could be identified as dilatated xylem (rather than true pith) by the presence of isolated vessel elements within it; these were easily visible with a handlens and dissecting microscope. In roots about 2.5 to 5.0 mm in diameter, the pith-like region was about 0.5 to 1.2 mm in diameter, but it was 3.4 mm in diameter in roots 12 mm wide, 10.0 mm in diameter in roots 22 mm wide, and 27 mm wide in roots 35 mm wide. Dilatation occurred in both the innermost, first-formed secondary xylem as well as the middle regions, but the outer regions of secondary xylem (the outermost 1.0–2.0 mm) had ordinary wood organization.

Root wood consisted of a ray system and an axial system (containing axially oriented cells such as vessel elements). Rays were extremely narrow, only 7.3 sd 2.3 µm wide and consisted of large, rounded parenchyma cells. The axial system consisted of vessel elements, paratracheal parenchyma in immediate contact with the vessels, and wide-band tracheids (WBTs). Wide-band tracheids are an unusual type of cell found in almost all cacti; they are short (range in *Lophophora*: 315 to 525 µm), broad spindle-shaped tracheids with secondary walls that are annular or helical (Mauseth et al. 1995; Mauseth 2004). There were no fibers in the wood. Just as rays were narrow, so were axial masses (98.4 sd 54 µm wide), and cross sections of root wood appeared to be rather solid when viewed with the naked eye or by dissecting microscope.

Structure of the shoot

Young regions of shoot differed from older regions by still having epidermis but lacking secondary xylem, phloem and bark. Epidermis was present on all aerial portions of shoots and had a blue-gray color. Hypodermis consisted of one layer of parenchyma cells. Both epidermis and hypodermis cells definitely did not have thickened walls so the shoot surface was very soft. Shoot cortex was always much thicker than the root's cortex-like region of secondary phloem. The thinnest cortex in an adult plant was 6 mm (in an old, below-ground portion of plant #1214) and the thickest was 32 mm at soil level in the same plant. Cortex was only 1.5 mm thick in the seedlings. The outermost cortex cells were columnar and aligned in palisades, the palisade cortex was about 3.5 mm thick. Cells of the inner cortex (located between the base of the palisade cortex and the phloem) consisted of large, rounded parenchyma cells. Cortical bundles were abundant throughout the inner cortex, extending to the base of the palisade cortex, and each bundle contained both xylem and phloem. Cortical bundles were easily visible by handlens and dissecting microscope.

A slender pith was present in the center of all stems. It was only 1.5 mm in

diameter in seedlings, from 4 to 6 mm in plants of medium size, and 10 to 27 mm in diameter in the largest plant (i.e., plant #1214, which had the greatest girth). It consisted of just parenchyma cells with very rare spherical crystals and no mucilage. There were no medullary bundles at all and no dilated metaxylem. The lack of xylem in the pith was easily visible by handlens and dissecting microscope: with both of these, shoot pith looked very clean and homogeneous whereas the root's pith-like region was coarse and granular due to xylem in the dilatated region.

Young shoots had a ring of collateral vascular bundles located between pith and cortex, older shoots had secondary xylem and phloem as well. Secondary xylem in shoots was similar to root wood. Rays were narrow (149 sd 134 µm, just one or two cells wide) and consisted of parenchyma cells with no sclerification at all. The axial system consisted of small numbers of vessels and paratracheal parenchyma but large amounts of WBTs. As in roots, axial masses were narrow, only about 318 sd 179 µm wide. No xylem fibers were present in any sample. Due to the narrow rays and axial masses and the lack of fibers, shoot wood resembled root and the two could not be distinguished if a microscope view contained only wood and no other tissues. Secondary phloem in shoots did not produce a cortex-like region as it did in roots; instead, as the sieve tube members stopped conducting, phloem collapsed into a thin, tangential band.

All subterranean portions of *Lophophora* shoots were covered by bark similar to that on older portions of roots. An unusual feature was that shoot bark occasionally contained crystals and vascular bundles, indicating that the cork cambium had arisen deeply enough in the shoot cortex to cut across cortical bundles; however, both crystals and vascular bundles were too small to be visible with a handlens examination of bark.

Structure of the hypocotyl

The hypocotyl is the short (less than 10 mm long) region located between the seedling shoot (epicotyl) and the seedling root. The structure of the hypocotyl in *L. williamsii* had characters of both the root and shoot. The center of all hypocotyls was root-like because it consisted of dilatated metaxylem and innermost secondary xylem, so it too was pith-like. It could be identified as not being a true pith by the presence of vessel elements and WBTs interspersed with the parenchyma cells. The outermost regions were true cortex, and even though a hypocotyl is not a part of the shoot, the hypocotyls of *Lophophora* had cortical bundles. Hypocotyl cortex width was wider than that of the cortex-like region in roots, narrower than the true cortex of shoots in each plant. All hypocotyl samples had abundant secondary xylem and phloem, which was similar to that in both roots and shoots. Hypocotyl bark was similar to that of shoots, having occasional bits of cortical bundle that had been cut off by a cork cambium located deep within the cortex.

TABLE 2. Distinguishing characters of shoots and roots of *L. williamsii*.

	Shoots	Roots
Outer tissues	True cortex; appears granular due to presence of cortical bundles. At least 5 mm or more thick.	Cortex like region; appears smooth due to lack of cortical bundles. At most only 3 mm thick.
Center	True pith; appears smooth due to lack of medullary bundles and lack of dilatated metaxylem. Width is not a reliable criterion.	Pith-like region; appears granular due to dilatated metaxylem and innermost secondary xylem.
Withered tubercles	Sometimes present, not always easy to identify if bark is rough.	Never present.
Lateral roots	Never present on shoots? May be confused with post-harvest adventitious roots.	Common on taproots, but could be absent.

DISCUSSION

This study shows that roots and shoots of *L. williamsii* differ significantly in several features. At least in fresh plants, the two organs can be distinguished easily and reliably using just a handlens or dissecting microscope (Table 2). Both root and shoot have an outer region that resembles cortex, but the true cortex of shoots has a granular appearance because it contains numerous cortical bundles (Fig. 15), as is true of many cacti (Sajeva & Mauseth 1991; Mauseth & Sajeva 1992). In contrast, the outer region of roots resembles cortex but is in fact an accumulation of secondary phloem, which has a very smooth appearance as seen with a handlens. The vascular bundles of lateral roots pass through this cortex-like region of secondary phloem, but because lateral roots are so sparse and because their vascular bundles are oriented vertically, there is little chance of confusing the shoot and root outer tissues. Roots of other cacti also have this outermost cortex-like region (Stone-Palmquist & Mauseth 2002). The true cortex of the root of *L. williamsii* is pure parenchyma (Fig. 16) and does not contain secondary phloem.

The center of shoots is occupied by true pith, which is homogeneous in appearance due to the lack of medullary bundles in *Lophophora williamsii* (Fig. 17). Medullary bundles are common in many species of cacti but lacking in others (Mauseth 1993). In the roots of most species, metaxylem either has no parenchyma or if it does, the parenchyma does not undergo proliferation, so that roots of most plants have no pith-like region at all and can easily be distinguished from shoots (Mauseth 1988). The pith-like region of roots in *L. williamsii* (Fig. 18) makes the roots look like shoots at first glance or with just the naked eye, but because the pith-like region in cacti originates by cell division in root metaxylem (Gibson 1978; Loza-Cornejo & Terrazas 1996), it has a granular appearance when examined with a handlens.

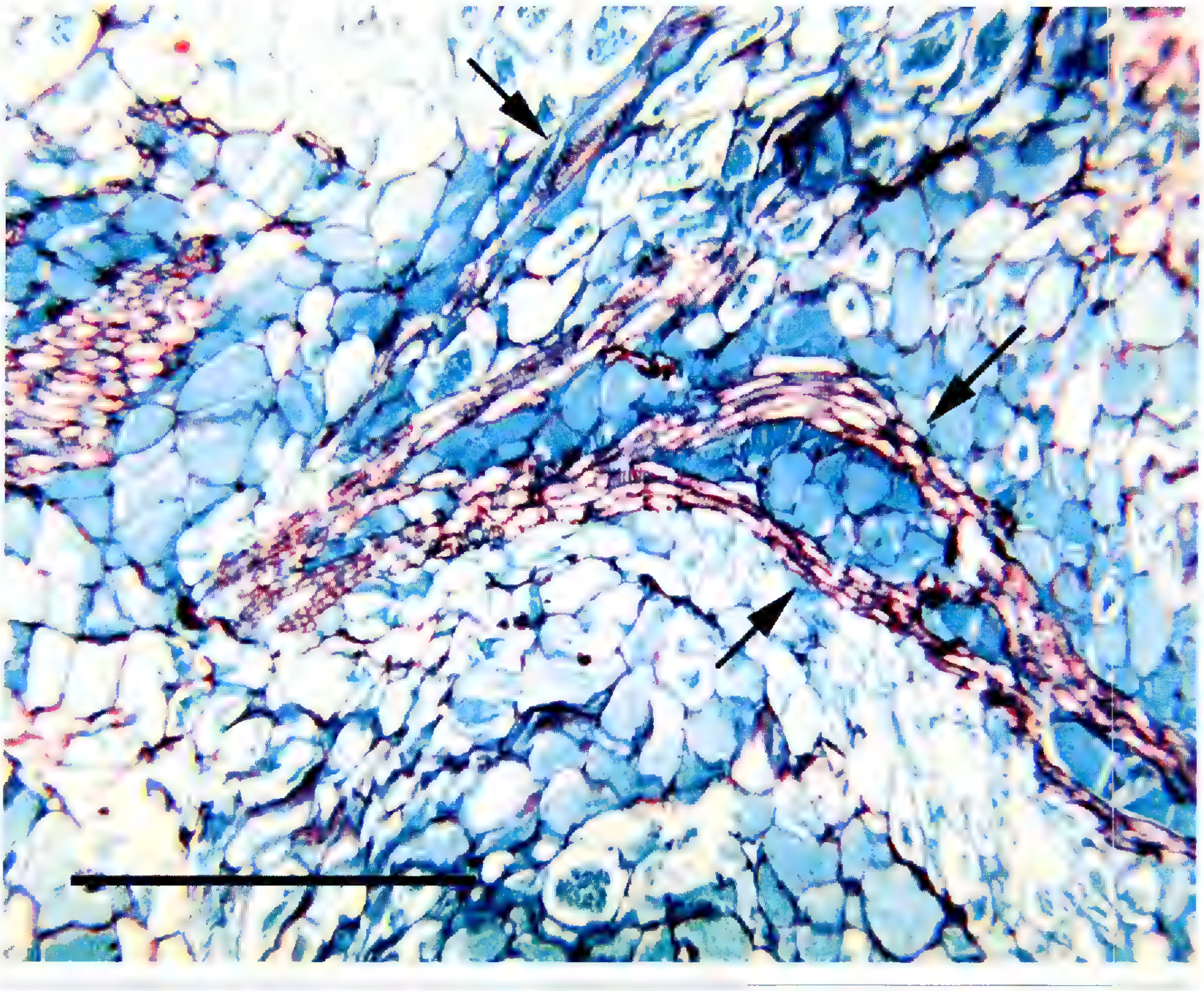


FIG. 15. Cortex of shoot of *L. williamsii*. Arrows indicate cortical bundles running through the parenchyma. All visible parenchyma cells are cortex parenchyma. Scale bar (lower left) = 1 mm.

Two characters might be useful for distinguishing shoots from roots without cutting plants open to examine the cortex-like regions and pith-like regions. Lateral roots emerged from the sides of other roots and from the sides of hypocotyls, but none was seen on any part of the three adult shoots we examined. It is possible that shoots had produced adventitious roots which had either broken off when the plants were collected or which had abscised before collection. No remnants of such roots were seen when we examined the sides of subterranean portions of shoots with a dissecting microscope, but these plant parts were so wrinkled and bark-covered that we could have missed any that were present. However, as we examined the microscope slides of subterranean portions of shoots, we did not encounter any vascular bundles that would have indicated adventitious roots had been present. One plant, examined in the field, had a root emerging from its side at about the same level as a lateral branch; if that root was emerging from the shoot rather than the hypocotyl then shoots as well as roots might bear roots. Now that anatomical characters can be used to distinguish roots from shoots, it will be possible to examine more plants in the

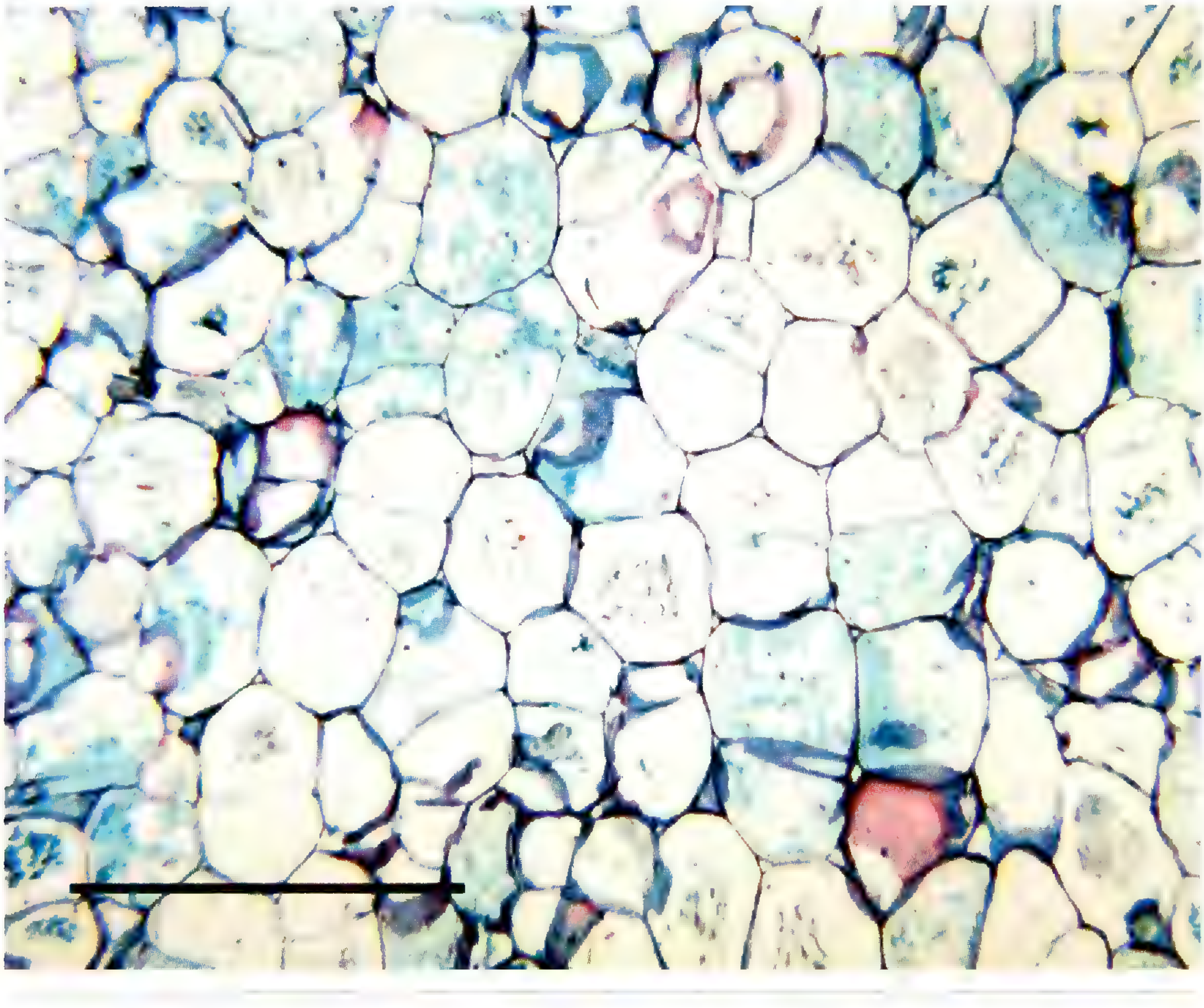


FIG. 16. Cortex of root of *L. williamsii*. All cells are cortical parenchyma cells. Absence of cortical bundles is conspicuous. Scale bar = 1 mm.

field to see how frequently shoots bear roots from their sides, and the extent to which such adventitious root development is associated with branching of subterranean stem tissue in response to peyote harvesting or removal of the apical meristem by natural processes.

If the below-ground portion of the plant has withered tubercles, it must be part of the shoot rather than root or hypocotyl. However, we did not find any withered tubercles on one of our adult specimens despite a search with a dissecting microscope. Apparently they either wither so much that they become unrecognizable or they abscise, so their absence cannot be used as proof that the structure is either hypocotyl or root. When trying to find withered tubercles in the field, one should search in a line continuous with the line formed by the rows of tubercles in the aerial shoot, because all tubercles are formed in rows (just as on the ribs of columnar cacti: Mauseth 2000).

If a plant remnant is to sprout and continue growing after its top has been harvested, the presence and health of these withered tubercles is important. If a plant is harvested by being cut too low, only root or hypocotyl will remain in

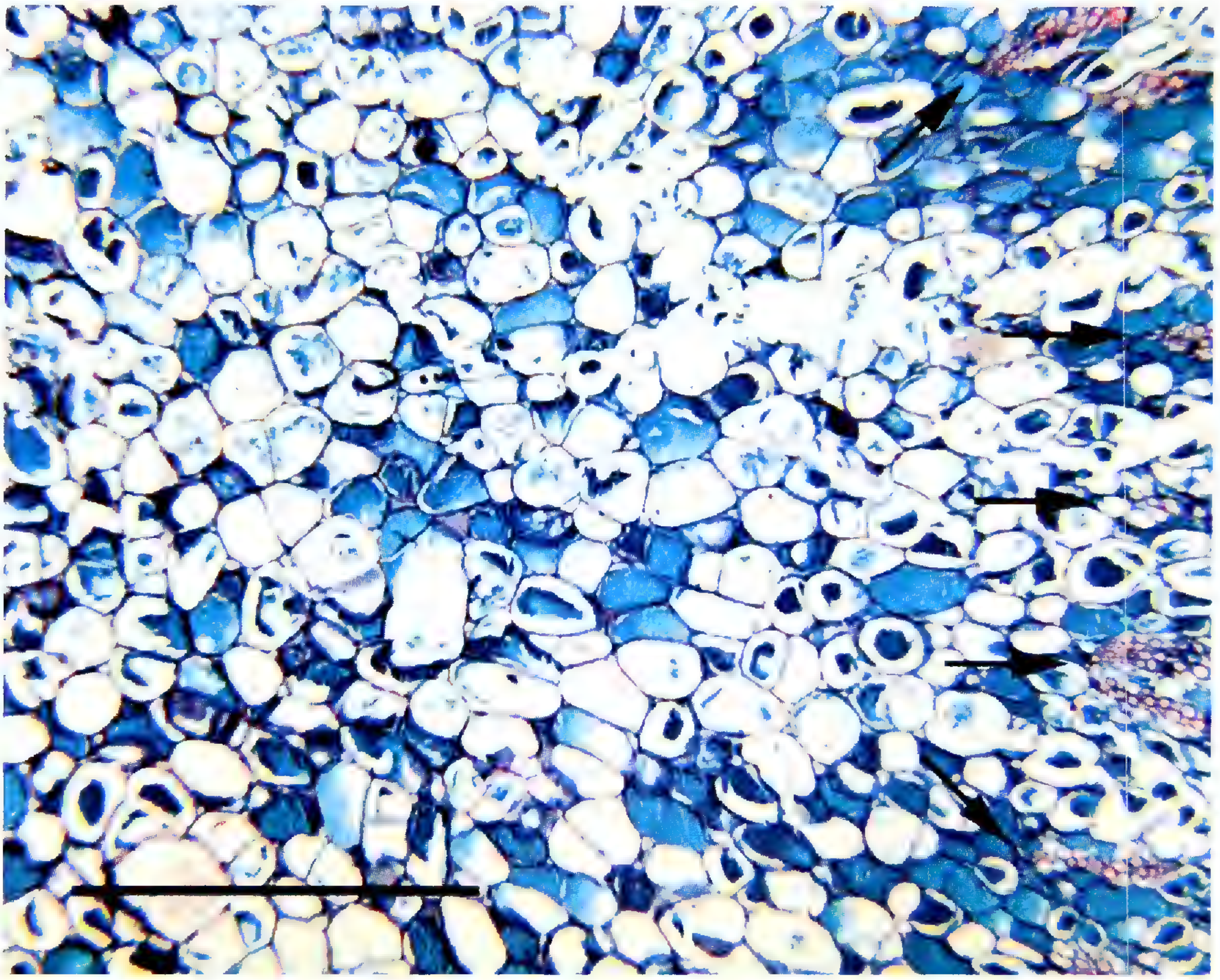


FIG. 17. Pith of center of shoot of *L. williamsii*, showing pith as pure parenchyma without xylem (center and left). Arrows (right) indicate the innermost primary xylem of the vascular bundles in the ring of bundles at the perimeter of the pith. Only part of the ring of vascular bundles is shown (right), and all the cells on the left are true pith. Scale bar = 1 mm.

the ground and neither of these have axillary buds, so neither can produce a bud to replace the harvested shoot. If the plant is harvested by being cut through the subterranean shoot, and if the remaining portion of shoot has healthy tubercles—withered but with an axillary bud—then the remaining portion should be able to sprout and grow and be ready for harvesting again in a few years. But if the remaining shoot has abscised all its tubercles, or if they have withered so much that they are no longer healthy, then the remaining piece of plant will not be able to sprout and will instead eventually die for lack of photosynthetic tissues. Tubercles located higher on the subterranean portion of the shoot are younger and presumably healthier than those lower down, deeper in the soil and closer to the root. If plants are harvested by cutting the subterranean shoot rather high—closer to soil level—the greater the chances are that the residual piece of plant will have healthy tubercles and will be able to re-sprout.

With the information discovered in the current study, we now have the tools to examine in detail the potential for regrowth after different types of harvest-

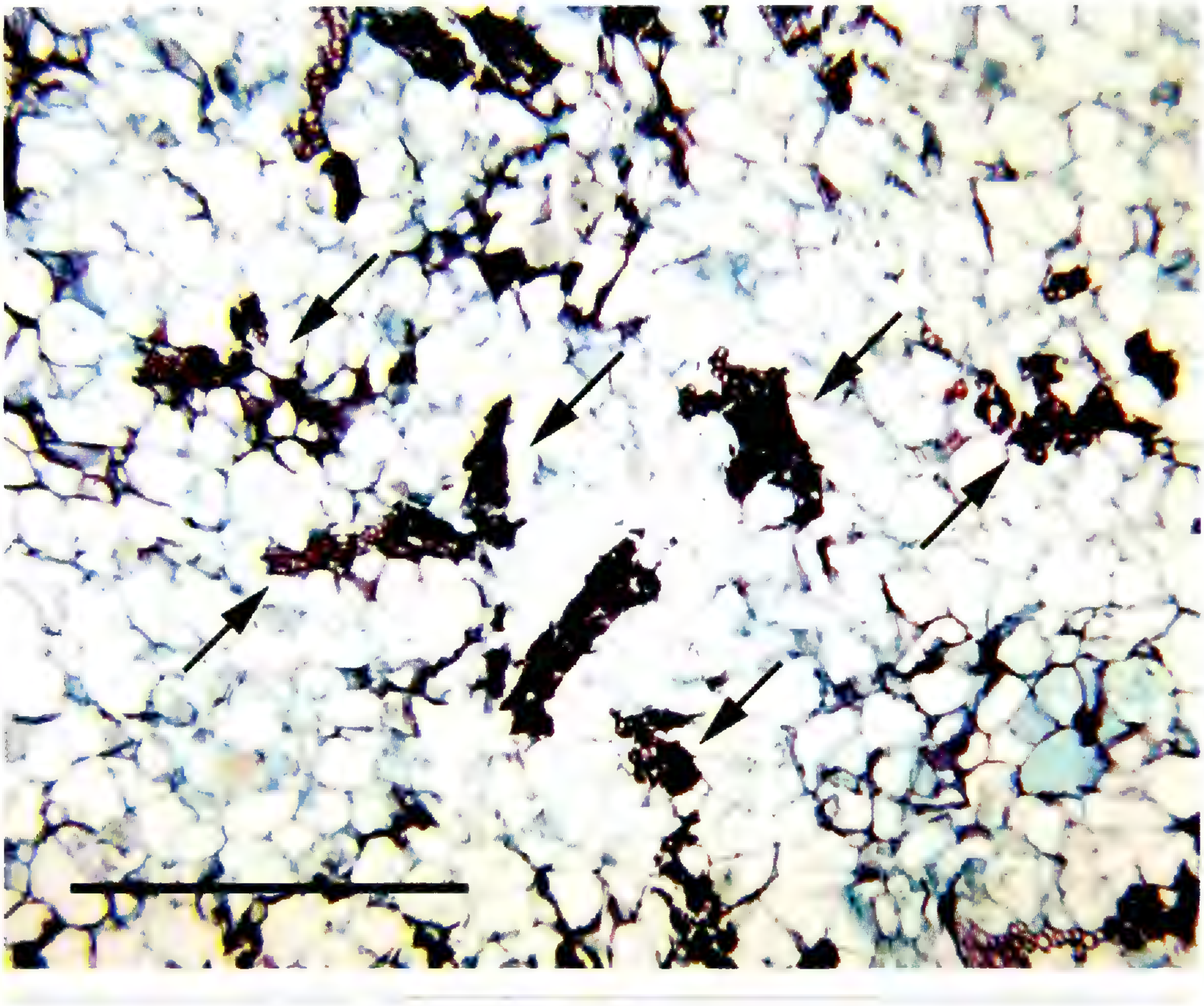


FIG. 18. Dilatated metaxylem of center of root of *L. williamsii*. All arrows indicate masses of dark-staining metaxylem tracheary elements. All parenchyma cells in the image are metaxylem parenchyma cells, not pith. Scale bar = 1 mm.

ing. A set of plants could be harvested at various depths below soil level with the certainty that all had been cut high enough that some shoot tissue had been left on the remaining plant portion. The harvested top of each could be examined for withered tubercles. Presumably if plants are cut so high that their harvested tops have several recognizable withered tubercles near the cut, then the remaining portion also has at least a few tubercles and will sprout. But if plants are cut so low that the harvested tops have few or no identifiable withered tubercles near the cut—and if the cut does pass through shoot tissue and not root tissue—then probably the remaining shoot also has few or no tubercles capable of sprouting. It is even possible to try cutting the plants through the hypocotyl to see if it is capable of forming adventitious shoot buds; that capacity is rare in hypocotyls but is known to occur in a few species.

Preliminary data on plants under greenhouse conditions were collected on 11 plants over a period of three years (not synchronically). Six plants were cut low (approximately 1.5 crown diameters below the base of the crown, and in every case at least 50 mm below the base of the crown). The distal subterra-

nean portions of those plants were then observed for at least eight months. No new stem branches were observed on any of the six low-cut plants. The other five plants were cut high (at about the base of the crown, and in no case more than 5 mm below the base of the crown) and similarly observed. One or more crown-bearing lateral branches from the decapitated subterranean stem were observed within five months on three of the five plants, and within eight months on all five high-cut plants.

Future studies include a similar greenhouse experiment on regrowth, with substantially larger numbers of plants and with varying measured depths of cut expressed as a fraction (or multiple) of crown diameter, so that crown diameter could be used as a practical guide for harvesting peyote in the field. It will be noted whether the cut goes through root, stem, or hypocotyl. That titration of the effect of depth of cut on regrowth in the greenhouse will be followed by a similar experiment conducted in the field, with individually identified and permanently marked plants. It is anticipated that results in the field may differ from greenhouse results, due to harsher environmental conditions in the field and the possibility that some of the smaller plants in the field may have been harvested previously, perhaps leaving less than the critical mass of subterranean stem tissue needed to regenerate viable photosynthetic stem tissue. These factors may affect regeneration and survivorship in all experimental groups.

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TAXONOMY AND CONSERVATION OF MEDICINAL PLANTS IN CANAL-IRRIGATED AREAS OF PUNJAB, PAKISTAN

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ABSTRACT

The taxonomic position of 131 medicinal plants from the canal-irrigated areas of Punjab belonging to 112 families and 52 genera is presented. Their life form, parts used and pharmaceutical uses are also described. The most important family was Fabaceae containing 21 medicinal species, followed by Apiaceae, Asteraceae, Lamiaceae, Solanaceae (6 species each), Cucurbitaceae, Malvaceae, and Poaceae (5 species each). Life form analysis of these medicinal plants indicates that all life forms are represented with the majority herbaceous. To conserve this natural wealth, an integrated strategy for both saving species and meeting the increased demand for medicinal plants is suggested. The main points of this strategy should include formulation of a comprehensive policy, increased ethnobotanical surveys and sustainable production of medicinal plants through their cultivation.

KEY WORDS: Canal irrigation, medicinal plants, taxonomy, pharmaceutical uses, conservation, Pakistan

RESUMEN

Se presenta la posición taxonómica de 131 plantas medicinales de las áreas irrigadas del canal del Punjab pertenecientes a 52 familias y 112 géneros. Se describen también las formas vitales, partes usadas y usos farmacéuticos. La familia más importante es Fabaceae con 21 especies medicinales, seguida por Apiaceae, Asteraceae, Lamiaceae, Solanaceae (6 especies cada una), Cucurbitaceae, Malvaceae, y Poaceae (5 especies cada una). El análisis de las formas vitales de estas plantas medicinales indica que están representadas todas con predominio de las herbáceas. Para conservar esta riqueza natural, se sugiere una estrategia integrada tanto para salvar las especies como para abordar la creciente demanda de plantas medicinales. Los puntos principales de esta estrategia serían incluir la formulaci—n de una pol'tica integral, incremento de estudios etnobotánicos y la producción sostenible de plantas medicinales mediante su cultivo.

INTRODUCTION

Pakistan has the distinction of having the largest contiguous gravity-flow irrigation system in the world. The Pakistani irrigation system has been greatly expanded since independence in 1947. This irrigation system serves as a lifeline for sustaining agriculture and is the main source of livelihood for the 70% population. Punjab has a well-developed irrigation system with a net work of

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canals, water channels and distributaries. The canal-irrigated areas account for 90% of agricultural production and employ 54% of the labor force (Khan 2002).

Pakistan is rich in plant resources with more than 6,000 plant species of higher plants (Nasir & Rafiq 1995). The irrigated areas of Punjab are rich in phyto-diversity, containing a wealth of cultivated crops, natural vegetation and wild flora (Ahmad 2003). This includes plants used in traditional herbal medicine. Research on medicinal plants in the irrigated areas of Punjab has been generally ignored in respect to developing a scientific understanding of the dynamics of natural resources, organization and evolution of human systems. This apparent lack of attention to irrigated, cropped areas has resulted in a paucity of scientific data about the natural vegetation of these areas. There are a few studies listing the medicinal plants from various regions of Pakistan (Ahmad & Waseem 2004; Athar & Ahamd 2004; Athar & Siddiqi 2004; Gill 2003). However, the irrigated areas of Punjab have not been explored adequately in floristic surveys, and a comprehensive documentation of the medicinal flora of the region also is lacking. Pressure on the wild plants of these areas is expected to increase with increasing agricultural, urban and industrial activities. The natural vegetation, including medicinal plants, of these areas is severely degrading, and there is an immediate need to protect and preserve these plant resources. This study is aimed at compiling a list of medicinal plants in canal-irrigated areas of Punjab with information about their taxonomic position, life form and pharmaceutical utilization of different plant parts. The study also explores the reasons for the decline of medicinal plants in the irrigated areas and suggests measures for their conservation.

MATERIALS AND METHODS

A literature search was conducted to determine the medicinal plants used for various disorders or diseases in canal-irrigated areas of Punjab, Pakistan (Baquar 1989, 1995; Joshi, 2003; Maheshwari 2003; Nasir & Ali 1972; Nasir & Rafiq 1995; Palaniswamy 2003; Rahim 1996; Rizvi 1998; Shaheen et al. 2003; Tivari & Tandon 2004; William & Ahmad 1999). Their taxonomic position, life form and pharmaceutical utilization of different plant parts were also determined. The plants included herbs, shrubs and trees. The genera were arranged alphabetically within each family. The English and local names that are commonly associated with these plants are provided. The nomenclature and classification followed Nasir and Ali (1972), and author citations followed Brummitt and Powell (1992).

RESULTS AND DISCUSSION

This study represents the first comprehensive survey of medicinal plants in the irrigated areas of Punjab, Pakistan with suggested strategies to conserve this natural wealth by both saving the medicinal plants and meeting their increased

TABLE 1. Some important medicinal plants in irrigated areas of Punjab.

Species	Local name	English name	Life form	Part used	Pharmaceutical uses
			MONOCOTYLEDONS		
Agavaceae					
Agave americana L.	Banskeora	Agave	Herb	Leaves, roots	Astringent
Alliaceae					
Allium cepa L.	Piaz	Onion	Herb	Bulbs, leaves, seeds	Anti-ulcerative
Allium sativum L.	Lehson	Garlic	Herb	Bulbs, leaves	Cholesterol, blood pressure
Asparagaceae					
Asparagus adscendens Roxb.	Musli sufaid	Garden asparagus	Shrub	Seeds, roots	Antidiarrhoeal, demulcent, galactogogue
Asphodelaceae					
Aloe vera (L.) Burm. f.	Gheekawar	Aloe	Herb	Whole plant	Cosmetic agent, febrifuge, anthelmintic
Cyperaceae					
Cyperus rotundus L.	Dela	Sweet cyperus	Herb	Roots	Diaphoretic, lithontriptic, liver tonic
Poaceae					
Bambusa bambos (L.) Voss	Tabasheer	Bamboo	Tree	Leaves, roots	Tonic, astringent antidiarrhoeal
Bambusa bambos (L.)Voss	Bans	Bamboo	Tree	Leaves, stem	Styptic, tonic, desiccative
Cymbopogon citratus (DC.) Stapf.	Izkhir	Russ grass	Herb	Stem	Antiseptic, stomachic, styptic
Cymbopogon jwarancusa (Jones) Schult.	Khowi ghas	Russ grass	Herb	Flowers	Detoxifier, astringent and tonic
Zea mays L.	Makai	Maize, corn	Herb	Flowers	Astringent, chloretic, diuretic and remedy for urinary infection
			DICOTYLEDONS		
Amaranthaceae					
Achyranthes aspera L.	Pathkanda	Prickly chaff	Herb	Whole plant	Astringent, diuretic

Table 1. continued

Species	Local name	English name	Life form	Part used	Pharmaceutical uses
Apiaceae					
Apium graveolens L.	Soya	Dill	Herb	Roots, seeds, stem	Rheumatism, arthritis, indigestion, flatulence, urinary tract inflammation and infection, neurasthenia, sleeplessness, anxiety and nervous breakdown
Centella asiatica (L.) Urb.	Brahmi booti	Pennywort	Herb	Leaves	Anti-inflammatory, diuretic
Coriandrum sativum L.	Dhania	Coriander	Herb	Leaves, stem	Antispasmodic, appetizer, aromatic
Daucus carota L.	Gajar	Carrot	Herb	Roots, stem	Aphrodiasic, exhilarant, diuretic
Foeniculum vulgare Mill.	Saunf	Fennel	Herb	Leaves, stem	Digestive, lactagogue, masticatory, flavoring agent
Trachyspermum ammi (L.) Sprague ex Turrill	Ajowan	Omum	Herb	Leaves, stem	Stimulant, antispasmodic
Apocynaceae					
Alstonia scholaris (L.) R. Br.	Shaitan-ka-Jhad	Devil's tree	Tree	Bark	Fever treatment
Nerium oleander L.	Kaner	Oleander	Shrub	Leaves, roots	Abortifacient, attenuant, anti-inflammatory
Tabernaemontana divaricata (L.) R. Br. ex Roem. & Schult.	Chandani	Nero's crown	Herb	Flowers, roots	Anthelmintic
Asclepiadaceae					
Calotropis gigantea (L.) W.T. Aiton	Madar	Gigantic swallowort	Shrub	Whole plant	Expectorant, alterative
Calotropis procera (Aiton) W.T. Aiton	Ak	Swallowort	Shrub	Whole plant	Diaphoretic, emetic, diuretic

TABLE 1. continued

Species	Local name	English name	Life form	Part used	Pharmaceutical uses
Asteraceae					
Ageratum conyzoides L.	Ajganda	Goat weed	Herb	Flowers, leaves	Emetic, digestive tonic
Calendula officinalis L.	Zergul	Calendula	Herb	Flowers	Diaphoretic, antiemetic
Carthamus tinctorius L.	Kusumba	Safflower	Herb	Flowers, stem	Emmenagogue, laxative, sedative, stimulant
Eclipta prostrata (L.) L.	Bhangra	Eclipta	Herb	Whole plant	Deobstruent, antiasthmatic
Matricaria recutita L.	Babuna	Chamimila	Herb	Flowers	Carminative, stimulant
Xanthium strumarium L.	Banukra	Cocklebur	Herb	Whole plant	Diaphoretic, emollient
Boraginaceae					
Cordia dichotoma G. Forst.	Lasora	Sebestan plum	Tree	Fruits	Demulcent, laxative
Heliotropium europaeum L.	Oont chara		Herb	Whole plant	Skin disorders
Brassicaceae					
Brassica juncea (L.) Czern.	Rai	Brown mustard	Herb	Seeds	Emetic
Lepidium sativum L.	Chandrasur	Common cress	Herb	Leaves, roots	Stimulant, anti-inflammatory
Sisymbrium irio L.	Khub kalan	Hedge mustard	Herb	Leaves, seeds	Skin disorders
Cactaceae					
Opuntia dillenii (Ker Gawl.) Haw.	Chappal	Prickly pear	Shrub	Whole plant	Demulcent, expectorant
Cannaceae					
Canna indica L.	Aqeeq	Indian Shot	Herb	Roots, seeds	Diaphoretic, diuretic, demulcent
Cannabinaceae					
Cannabis sativa L.	Bhang	Indian hemp	Herb	Flowers, leaves	Sedative, narcotic
Capparidaceae					
Capparis spinosa L.	Karir	Capper plant	Shrub	Roots	Anti-inflammatory, anti-flatulent, resolvent
Cleome gynandra L.	Hulhul	Caravalla seed	Shrub	Leaves, seeds	Rubefacient, anthelmintic
Cleome viscosa L.	Hurhur	Wild mustard	Herb	Leaves, seeds	Rubefacient, anthelmintic

Table 1. continued

Species	Local name	English name	Life form	Part used	Pharmaceutical uses
Chenopodiaceae					
Chenopodium album L.	Bathu	White goose foot	Herb	Seeds	Anthelmintic
Dysphania ambrosioides (L.) Mosyakin & Clements	Sak	Mexican tea	Herb	Seeds	Vermifuge
Combretaceae					
Terminalia arjuna (Roxb. ex DC.) Wight & Arn.	Arjan	Arjun tree	Tree	Bark	Stomachic, anti-ischemic and cardioprotective
Terminalia bellirica (Gaertn.) Roxb.	Bahira	Beleric myrobalan	Tree	Fruits	Bronchodilatory, antispasmodic, antiphlegmatic, expectorant and sedative activities
Terminalia chebula Retz.	Harir	Bidda nut	Tree	Fruits	Stomachic, alterative
Convolvulaceae					
Cuscuta reflexa Roxb.	Akas bel	Dodder	Herb	Seeds	Carminative, alterative, anodyne
Crassulaceae					
Kalanchoe pinnata (Lam.) Pers.	Zakhame hayat	Life plant	Herb	Leaves	Antiseptic, styptic
Cucurbitaceae					
Citrullus colocynthis (L.) Schrad.	Tumma	Colocynth	Herb	Fruit, roots	Anthelmintic, antipyretic
Citrullus lanatus (Thunb.) Matsum. & Nakai var. *lanatus*	Tarbooz	Water melon	Herb	Fruits, seeds	Laxative, brain tonic
Lagenaria siceraria (Molina) Standl.	Kaddo	Gourd	Herb	Seeds	Brain tonic
Luffa acutangula (L.) Roxb.	Ghia tori		Herb	Fruits, seeds	Bitter tonic, diuretic
Momordica charantia L.	Karela	Bitter gourd	Herb	Fruits, leaves, seeds	Anthelmintic, purgative
Euphorbiaceae					
Chamaesyce hirta (L.) Millsp.	Dhodak	Snake weed	Herb	Leaves, stem	Purgative, rubefacient
Euphorbia neriifolia L.	Thanda thor	Milk bush	Tree	Latex, roots	Purgative, expectorant, antispasmodic

TABLE 1. continued

Species	Local name	English name	Life form	Part used	Pharmaceutical uses
Phyllanthus niruri L.	Bhoin avail	Myroblan	Herb	Leaves, roots	Diuretic, astringent, bitter tonic
Ricinus communis L.	Arind	Castor oil	Shrub	Leaves, seeds	Emetic, anti-inflammatory
Fabaceae (Caesalpinioideae)					
Bauhinia purpurea L.	Kaliar	Purple Bauhinia	Tree	Bark, flowers, flower buds	Purgative, indigestion, body pain
Bauhinia semla Wunderlin	Kandla	Bauhinia	Tree	Bark, leaves, flowers	Astringent, diarrhea, dysentry
Bauhinia variegata L.	Kachnar	Mountain ebony	Tree	Bark, flower buds, roots	Blood purifier, anthelmintic
Cassia fistula L.	Amaltas	Golden shower	Tree	Fruits, leaves, roots	Emollient, febrifuge
Chamaecrista absus (L.) H.S. Irwin & Barneby	Chaksu	Chaksu	Herb	Leaves, seeds	Astringent, detersive, heamotonic, opthalmic
Senna alata (L.) Roxb.	Dadmurdan	Ringworm shrub	Tree	Leaves	Purgative, expectorant, aperient
Senna alexandrina Mill.	Sana	Senna	Herb	Leaves	Purgative
Tamarindus indica L.	Imli	Tamarind	Tree	Bark, leaves, fruits	Cooling, antibilious
Fabaceaae (Mimosoideae)					
Acacia modesta Wall.	Phulai		Tree	Gum	Emollient
Acacia nilotica (L.) Delile	Kikar	Acacia	Tree	Flowers, leaves	Emollient, astringent, styptic
Albizia lebbeck (L.) Benth.	Siris	Lebbek tree	Tree	Bark, leaves	Astringent, oral therapy
Mimosa pudica L.	Chhui-mooi	Touch me not	Herb	Leaves	Emetic, renal diseases
Fabaceae (Papilionoideae)					
Alhagi maurorum Medik.	Jawansa	Camel's thorn	Shrub	Whole plant	Laxative, demulcent, expectorant
Clitoria ternatea L.	Gokarni	Butterfly pea	Herb	Roots, seeds	Cathartic, demulcent
Cullen plicata (Delile) C.H. Stirt.	Bakuchi	Babchi	Herb	Seeds	Anthelmintic, diaphoretic
Erythrina stricta Roxb. var. *suberosa* (Roxb.) Niyomdham	Pangra	Coral tree	Tree	Bark	Cathartic, anthelmintic

TABLE 1. continued

Species	Local name	English name	Life form	Part used	Pharmaceutical uses
Indigofera tinctoria L.	Neel	Indigo plant	Herb	Whole plant	Deobstruent, alterative
Sesbania grandiflora (L.) Pers.	Bansa	Sesbania	Tree	Roots, flowers	Rheumatism, fever, diabetes
Sesbania sesban (L.) Merr.	Janter	Sesbania	Shrub	Leaves, flowers	Suppuration, anti-fertility
Trigonella foenum-graecum L.	Methi	Fenugreek	Herb	Leaves, seeds	Aperient, nutritive, expectorant
Vigna unguiculata (L.) Walp. subsp. *cylindrica* (L.) Verdc.	Kulatha	Horse gram	Herb	Seeds	Astringent, diuretic, lithontriptic
Lamiaceae					
Lallemantia royleana (Benth.) Benth.	Tukham-i-balanga		Herb	Seeds	Cooling, mucilaginous, anti inflammatory
Mentha arvensis L.	Podina	Mint	Herb	Whole plant	Carminative
Mentha ×piperita L.	Podina	Peppermint	Herb	Leaves	Aromatic oil, digestive disorders
Ocimum basilicum L.	Niazbo	Sweet basil	Herb	Flowers, seeds	Carminative, expectorant
Ocimum tenuiflorum L.	Tulsi	Holy basil	Herb	Flowers, leaves, roots	Stimulant, antiseptic
Salvia plebeia R. Br.	Salbia	Sage	Herb	Seeds	Treating boils and wounds
Linaceae					
Linum usitatissimum L.	Alsi	Linseed	Herb	Seeds	Diuretic, emollient
Lythraceae					
Lawsonia inermis L.	Mehndi	Henna plant	Shrub	Whole plant	Hair tonic, hepatic disorders
Malvaceae					
Abutilon bidentatum A. Rich.	Pattaka	Country mallow	Herb	Leaves, seeds	Demulcent, diuretic
Abutilon indicum (L.) Sweet	Peeli booti	Country mallow	Shrub	Leaves, roots, seeds	Demulcent, laxative, sedative
Gossypium herbaceum L.	Kapas	Cotton	Herb	Seeds	Detersive, emollient, expectorant
Malva sylvestris L.	Khubazi	Common mallow	Herb	Fruits, leaves	Throat infections
Sida cordifolia L.	Simak	Country mallow	Shrub	Leaves, roots	Astringent, diaphoretic

TABLE 1. continued

Species	Local name	English name	Life form	Part used	Pharmaceutical uses
Meliaceae					
Azadirachta indica A. Juss.	Neem	Margosa tree	Tree	Whole plant	Adrenalgic stimulant, dyspepsia, skin diseases, insecticidal
Melia azedarach L.	Drek	Persian lilac	Tree	Flowers, leaves	Anthelmintic, antispasmodic
Toona ciliata M. Roem.	Tun	Indian mahogany	Tree	Bark	Astringent
Moraceae					
Ficus benghalensis L.	Bar	Banyan	Tree	Leaves, latex	Astringent, viscous, resolvent, desiccative
Ficus religiosa L.	Pipal	Pipal tree	Tree	Bark, fruits	Astringent, antiasthmatic
Ficus virens Aiton	Pilkhan		Tree	Fruits, stem	Astringent, stomachic
Moringaceae					
Moringa oleifera Lam.	Soanjan	Horse rad'sh tree	Tree	Flowers, leaves	Anthelmintic, antipyretic
Myrtaceae					
Barringtonia acutangula (L.) Gaertn.	Jugar	Indian Oak	Tree	Bark, roots, seeds	Astringent, emetic
Myrtus communis L.	Wilayti mehndi	Myrtle	Shrub	Fruits, leaves	Antiseptic, disinfectant
Psidium guajava L.	Amrood	Guava	Tree	Fruits, seeds	Astringent, febrifuge, antiseptic, laxative
Nyctaginaceae					
Boerhavia diffusa L.	Itsit	Hog weed	Herb	Leaves, roots	Diuretic, diaphoretic, anthelmintic
Mirabilis jalapa L.	Gul-i-abbas	Four o'clock plant	Shrub	Leaves, roots	Demulcent, antispasmodic
Nymphaeaceae					
Nelumbo nucifera Gaertn.	Kanwal	Water lily	Herb	Fruits, leaves	Cardiac tonic, demulcent
Nymphaea lotus L.	Nilofar	White lotus	Herb	Flowers	Cardiac tonic, hepatic disorders

TABLE 1. continued

Species	Local name	English name	Life form	Part used	Pharmaceutical uses
Oleaceae					
Jasminum officinale L.	Chambeli	Jasmine	Shrub	Flowers, leaves	Anthelmintic, diuretic
Nyctanthes arbor-tristis L.	Kuri	Night jasmine	Shrub	Leaves, seeds	Antibilious, laxative
Oxalidaceae					
Oxalis corniculata L.	Surchi	Indian sorrel	Herb	Leaves	Anti-scorbutic, refrigerant
Papaveraceae					
Argemone mexicana L.	Stayanasa	Yellow thistle	Herb	Whole plant	Alterative, stimulant
Pedaliaceae					
Sesamum indicum L.	Til	Sesame	Herb	Seeds	Aphrodiasic, fattening, nourishing
Plantaginaceae					
Plantago ovata Forssk.	Isabaghol	Plantain	Herb	Bark, seeds	Cooling, mucilaginous, anti-inflammatory
Plumbaginaceae					
Plumbago zeylanica L.	Chitrak	Lead wort	Herb	Roots	Stimulant, antiseptic, detersive, refrigerant
Portulacaceae					
Portulaca oleracea L.	Dholica	Purslane	Herb	Seeds	Demulcent, diuretic, astringent
Ranunculaceae					
Nigella sativa L.	Kalonji	Black cumin	Herb	Seeds	Diuretic, galactagogue, stimulant
Rhamnaceae					
Ziziphus jujuba Mill.	Beri	Jujube	Tree	Leaves, seeds	Anti-inflammatory
Rutaceae					
Aegle marmelos (L.) Corrêa	Bel	Bil	Tree	Flowers, leaves	Laxative, expectorant
Salvadoraceae					
Salvadora oleiodes Decne.	Pil	Tooth brush tree	Tree	Bark, leaves, seeds	Vesicant, stimulant
Salvadora persica L.	Pilu	Mustard tree	Tree	Fruits, leaves	Diuretic, anthelmintic

TABLE 1. continued

Species	Local name	English name	Life form	Part used	Pharmaceutical uses
Sapindaceae					
Cardiospermum halicacabum L.	Kanphuti	Baloon vine	Herb	Whole plant	Demulcent, laxative
Scrophulariaceae					
Bacopa monnieri (L.) Pennell.	Brahmi	Thyme Gratiola	Herb	Whole plant	Febrifuge, nervine
Simaroubaceae					
Ailanthus excelsa Roxb.	Maharuk	Talbot	Herb	Bark, leaves	Astringent, febrifuge
Solanaceae					
Capsicum annuum L.	Mirch	Red pepper	Herb	Leaves, seeds	Pungent, sialgogue
Datura metel L.	Datura	Apple of Peru	Herb	Leaves, seeds	Narcotic, toxic, antispasmodic
Lycopersicon esculentum Mill.	Tamatar	Tomato	Herb	Fruits	Antioxidant, carminative
Solanum nigrum L.	Mako	Black nightshade	Herb	Roots, seeds	Cardiac tonic, diaphoretic
Solanum virginianum L.	Kandiari	Indian Solanum	Herb	Whole plant	Expectorant, diuretic
Withania somnifera (L.) Dunal.	Asgandh	Winter cherry	Shrub	Whole plant	Anthelmintic, stimulant
Tiliaceae					
Corchorus olitorius L.	Kost	Jute plant	Herb	Seeds, leaves	Carminative, astringent
Grewia asiatica L.	Phalsa	Grewia	Herb	Fruits	Carminative
Zingiberaceae					
Curcuma longa L.	Haldi	Turmeric	Herb	Seeds	Antimutagenic, antioxidant
Zygophyllaceae					
Fagonia cretica L.	Dama	Prickly cover	Shrub	Leaves	Refrigerant, febrifuge
Peganum harmala L.	Harmal	Harmal	Herb	Roots, seeds	Narcotic, hypnotic, emetic
Tribulus terrestris L.	Pakhra	Puncture vine	Herb	Seeds	Aphrodisiac, diuretic

demands in the traditional health care system. A total of 131 medicinal plant species in 112 genera belonging to 52 plant families are reported from the canal-irrigated areas of Punjab (Table 1). It is interesting to note that most of the medicinal plants were Dicots (48 families), while Monocots constitute only a minor fraction of them (3 families). The most important family was Fabaceae containing 21 medicinal species. This was followed by Apiaceae, Asteraceae, Lamiaceae, Solanaceae (6 species each), Cucurbitaceae, Malvaceae, and Poaceae (5 species each). Life form analysis of these medicinal plants indicated that all life forms were represented, but the majority belonged to herbaceous forms (Table 1). Herbs (80 species) were found to be the most common life form followed by trees (32 species) and shrubs (19 species). Most frequently utilized plants parts included leaves (54 species), seeds (44 species) and roots (27 species). Whole plants of 18 species were utilized in herbal medicine. The bark, fruits and flowers (16 species each) and stem and branches (10 species) also served as medicines. Onion and garlic bulbs and gums and latexes from some of the plants were also used as medicines.

The biological and physical changes associated with fragmentation and loss of habitats and canal irrigation have many residual and secondary effects that aggravate the problem of phyto-diversity loss. These include pollution, decline of soil fertility, water logging, the salinization or acidification of soil and water, the siltation of water channels and increased desertification. Among these, salinity and water logging of soils in Punjab are the most important problems (Davidson 2000). Saline soils, high temperatures and increased rate of evaporation, and limited water supply pose a serious limit back on the growth and distribution of native plants (Hussain et al. 2003). Desertification is another threat to native plants of Punjab because it particularly affects the biota of areas with 200-800 mm of average rainfall (Khan 2000). The activities that lead to or enhance desertification include cultivation of unsuitable terrains and soils, over-grazing and lack of proper livestock management practices, and excessive removal of shrubs and trees for fuel wood (Ahmad & Waseem 2004). This has resulted in the loss of many herbaceous species, including medicinal plants, in many areas of Punjab (Khan 2000).

The irrigated areas of Punjab are as rich in phyto-diversity and deserve all possible protection and conservation measures to prevent loss of wild plants. The conservation and sustainable management of medicinal plants requires a strategic action at different levels. As part of the conservation of medicinal plants, the management and use of agricultural lands need major revamping. Farmers should realize that their methods of land use and farming practices affect the surrounding environment and the organisms in that environment. As a first step towards better land management, clearing and fragmentation of native vegetation should be stopped and the extent of native plant reserves should be increased.

Medicinal plants are one of the few natural products of developing countries that could be marketed at higher prices (Athar & Ahmad 2004; Shaheen et al. 2003). The ever growing market and demand for herbal ingredients creates possibilities for cultivation of medicinal plants as crops (Hussain et al. 2003). Such efforts could provide a substantial supply of herbal plants and help increase the income of the farmers. With continuous increase in use and demand for herbal products, the gap between demand and supply is widening (Crockett & Khan 2003). It is estimated that world trade in medicinal plants and related products may reach to US$ 5 trillion by 2050 (Purohit & Vyas 2005). Most of the demand so far has been met from wild sources, which cannot last much longer. Since medicinal plants are a source of additional earnings and traditional treatments for a major part of rural population, it is recommended that these plants may be propagated and domesticated as cash crops. Thus, cultivation of medicinal plants could be a potential source of economic development that would also meet conservation objectives.

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NOTES ON THE LIFE AND WORK OF JAMES BRIGHAM MCFARLIN, FLORIDA BOTANIST

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ABSTRACT

James Brigham McFarlin contributed to Florida botany and his work provided a rare glimpse into the diversity that once existed in the central part of the state three-quarters of a century ago.

RESUMEN

James Brigham McFarlin contribuyó a la botánica de Florida y su obra dio una ojeada rara a la diversidad que existía en Florida central hace 75 años.

James Brigham McFarlin (1901–1969) was among a small group of botanists whose work contributed to a better understanding of Florida's flora through explorations and collections during the first half of the 20th Century. Unlike J.K. Small and other prominent botanists who visited Florida to collect and explore, Jim McFarlin (Fig. 1) was a Florida resident. He used his familiarity with the area—particularly the Lake Wales Ridge in the central peninsula—his enthusiasm and a keen eye to collect and record specimens that he regarded as new species or new forms of known species as well as species that were previously undocumented in the state. Apart from a brief mention in Wunderlin et al. (2003), nothing appears to have been written about McFarlin's life and work. This paper is an attempt to fill that gap.

Jim McFarlin was born November 24, 1901, in New York City. He attended Mercersburg Preparatory School in Mercersburg, Pennsylvania and went on to attend Syracuse University, where he received a degree from the New York State College of Forestry in 1925. He then joined his parents, Robert Roy and Grace B. McFarlin, in Winter Haven, Florida. The elder McFarlins had moved to Winter Haven in 1918 (Burr 1974), where the elder McFarlin had purchased land and operated a citrus grove. After moving to Winter Haven, Jim McFarlin was president and manager of Winter Haven Ornamental Nurseries east of Winter Haven (City Directory 1928). However, he was not a particularly successful businessman and survived at times only through his father's financial assistance (M. Bryant, pers. comm.).

His primary interest at that time was botany, not the nursery business. He followed that interest from 1930 to 1933 with an assistantship from the University of Michigan, where he pursued a doctorate. His graduate assistant stipend was $600 a year (Cherie Peterson, pers. comm.). His thesis work involved exten-

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Fig. 1. James Brigham McFarlin (front left).

sive collecting in Polk County and some surrounding areas in connection with the preparation of his dissertation (McFarlin 1935). No degree was awarded and his assistantship was not renewed after 1933.

By 1933 McFarlin was married with one child, unemployed, and in the

depths of the Depression. He found temporary work with the U.S. Department of the Interior's Civilian Conservation Corps. He was employed initially in the Chippewa National Forest, Cass Lake, Minnesota. In 1934 he was transferred to the CCC camp near Sebring, Florida, where work was underway to develop Highlands Hammock State Park, one of Florida's first state parks. McFarlin became the botanist at the Highlands Hammock Botanical Garden and Arboretum and served on the Executive Committee of its Botanical Garden Association (Altvater 1966). He was recommended for that position by Harley Harris Bartlett, then chairman of the Department of Botany and director of the Botanical Garden at the University of Michigan (letter, 17 February 1934, to Harry Lee Baker, Florida state forester). Dr. Bartlett had been a member of McFarlin's graduate committee at Michigan.

McFarlin was responsible for preparing some of the early interpretative materials for Highlands Hammock State Park (McFarlin 1939). Some of his field notebooks containing notes on specimens he collected during his field work in Florida were found around 2000 during an inventory of historical artifacts at the park, but their importance was not recognized until 2005. The pages in the notebooks are being digitally copied for use in a planned exhibit at the park's CCC museum (D. Smith, pers. comm.).

McFarlin lived in the Sebring area until at least 1942, but later moved back to Winter Haven (Burr 1974) and lived there until moving to Bradenton in 1949, shortly after the death of his father in October 1948. In Bradenton, probably because of the inheritance he received from his father's estate, he was able to resume his career in the nursery business. He operated Begonia Gardens there until his death on March 10, 1969 (Anonymous 1969). According to his obituary, he and his wife Marie, who he married in 1927, had a son, James R. McFarlin, a daughter, Sarah Wells, and four grandchildren.

McFarlin began his botanical collection as early as 1923, according to correspondence between 1924 and 1935 with J.K. Small (Florida State Archives), from whom he sought information and advice on specimens he collected and for whom he collected specimens. McFarlin's early collections were deposited with the herbarium at Syracuse University. Later collections involving about 5,000 specimens were sent to the herbaria at the University of Michigan and the University of Florida (McFarlin 1935). Some of his specimens have been deposited in the U.S. National Arboretum (Gann et al. 2002) and other locations.

In addition to vascular plants, McFarlin was also interested in mosses and liverworts. He at one time had prepared displays of some of his specimens in mahogany cases (M. Bryant, pers. comm.). He eventually donated his bryological collections to the University of Florida and to the National Museum of Canada in Ottawa (K. Perkins, pers. comm.). That collection supported a publication (McFarlin 1937) in which he concluded that the local moss population in Polk County, was "relatively depauperate of species." McFarlin collected in south

Florida as well and was noted as having collected the first specimens for a handful of species in that region of Florida (Gann et al. 2002).

McFarlin's major botanical exploration, which resulted in the collection of the bulk of the specimens, occurred in 1930 and 1931 while a graduate student. McFarlin collected throughout Polk County, a large (5,300 sq. km.) county located in the central part of Florida. At the time he was collecting the area was still relatively undeveloped. He made repeated collecting trips to several locations, including Marion Creek near Haines City, Lake Deer near Winter Haven and Kissengen Spring near the Peace River south of Bartow.

McFarlin never received his doctorate, but the reasons are unclear. According to the University of Michigan's Transcript and Certification Office, he was enrolled as a graduate student from 1930 to 1933 (M. Henderson, pers. comm.). In a September 1, 1935, letter to J.K. Small he wrote of having completed his dissertation and informed. Small he was ready to submit it to his doctoral committee. He wrote on April 29, 1935, to E B. Mains, one of his professors at the university and was told that. McFarlin should first submit his thesis to John H. Ehlers, chairman of his committee. Yet there is no record of his dissertation's ever having been received at the University of Michigan (E. Voss, pers. comm.). Although McFarlin's university transcript is unavailable because of claimed privacy concerns, the Certification and Transcript Office agreed to examine the transcript and said it does not indicate why Mr. McFarlin did not complete his degree. (M. Henderson, pers. comm.).

McFarlin's 1935 dissertation, however, has survived. A copy of the original document was completely retyped by Margaret L. Gilbert, a biology professor at Florida Southern College in Lakeland, Florida, in 1961, with duplicates given to several individuals and institutions within the state. The thesis is a tightly written work of 228 pages (as retyped), the bulk consisting of an enumeration of the vascular flora arranged by family. Each species is reported by scientific name, synonyms, and at times common names, with a brief statement of habitat and location. Nearly all entries also carry McFarlin's field collections numbers for the species. A key is given to the species of genera with more than a single species.

As a supplement to the main body of the thesis, McFarlin provided a statistical tabulation of its contents: 159 families, 560 genera, and 1131 species. He then recorded 131 species he regarded as weeds, and 53 species as introductions. He gave further complete tabulations for the species of "high pine land," "scrub," "high hammock," "flatwoods," "prairie," "low hammock," "swamp," "bayhead," "cypress head," "marsh," "lakes," "streams," "clay pits," "bogs," "shallow ponds and drainage ditches," "shores," and "sandy beaches." He followed this with lists of "epiphytes," "parasites," 11 and "saprophytes."

McFarlin recorded in the last pages of his thesis what he believed to be 2 species new to the United States, 7 new to Florida, 7 species new to science, 7 new varieties, 14 new forms, and 3 new combinations.

McFarlin's 1935 thesis and his supporting specimens (mostly those at the University of Florida) have provided clues for further botanical exploration. His work, though unpublished and little known, offers a rare glimpse of the former distribution and abundance of many species that are now much less common in central Florida.

A few examples are worth mentioning. McFarlin reported collecting the first U.S. specimen of Hairlike Spikerush (*Eleocharis nana*), a species that is still considered rare and has been collected from only two other Florida counties (Wunderlin & Hansen 2000). However, the collection of this specimen underlines one of the problems with reviewing McFarlin's work. The reported collection site (Lake Lynch near Lake Alfred) is unknown and appears neither on modern maps nor on maps from that period, such as the 1927 Polk County Soil Survey that he cited in his dissertation. Several other sites where McFarlin reported collecting regularly, such as Highland Gully near Lakeland and Faulkner Hammock near Bartow, are similarly undocumented as to their locations other than being near some present-day city. In an undated letter to E.B. Maines, McFarlin refers to a map "showing all of my collecting locations," but no such map was included in any of the known copies of his doctoral dissertation.

In some cases, McFarlin found species beyond their known ranges in Florida at the time, such as the terrestrial orchid Wild Coco (*Eulophia alta*). Until then the species was known only from the Big Cypress Swamp area, according to Small (1933).

McFarlin claimed (McFarlin 1935) to have collected a number of specimens that either represented species previously unknown to Florida or entirely new species. In the case of the new species for Florida, it appears possible that some of the claimed discoveries, such as Nash's blue-eyed grass (*Sisyrinchium brownei*) or *Ludwigiana brevipes*, may have been misidentified since modern summaries of Florida's botanical life, notably Wunderlin and Hansen (2000), do not include them. However, others such as *Verbena bonariensis* and *Commelina benghalis* are known to exist in Florida and are actually quite common.

McFarlin's only published new species was a small- leaved sand holly that he named *Ilex pygmaea* (McFarlin 1932). He was unaware that the tree had been named previously, by Small in 1924, and his name is now considered a synonym of the scrub holly, *Ilex opaca* var. arenicola. All but one of the six other new species mentioned in his unpublished thesis had no nomenclatural standing and were largely overlooked. The exception, which has recently received attention, is the pink-flowered Scrub (McFarlin's) Lupine, which McFarlin named *Lupinus aridorum*. This plant was collected by other workers as early as 1900 (U.S. Fish and Wildlife Service 1993) but McFarlin was the first to consider it a separate species. McFarlin did not describe the species. It was not described until years after his death by Beckner (1982), who also knew the plant in the field, recognized its distinct features, and gave it proper treatment. Though

related to *Lupinus westianus*, a similar species of the Florida panhandle, it is quite separate in its range and is clearly an endemic of the central peninsula. McFarlin described the plant as "infrequent to locally abundant," but with development of the area it has become quite rare, and is now classified as endangered by the state and federal agencies (Coile & Garland 2003). As a result, the future survival of this species remains a concern. The only protected populations of the plant occur at a federal preserve in Eagle Lake south of Winter Haven and at a county park in the Orlando area (Kane 2003). Unprotected populations persist in a handful of other sites in Central Florida. Establishment of other protected populations—including one site near Winter Haven where McFarlin did much of his collecting—has been proposed (Kane 2003) and would seem to a fitting tribute to McFarlin's work.

McFarlin commented on other endemic plants of the central ridge. Another species he believed to be new was a small-leaved variety of grape that is widespread in the scrub habitat. He gave it the name *Muscadina pygmea*. Later observers have noted the plant, but have never given it formal status by publishing its name and description. Recently McFarlin's original specimens have been tracked down (in the Smithsonian Institution) and a paper is in press to give it formal recognition as a variety of the muscadine grape, *Vitis rotundifolia* (D.B. Ward, pers. comm.).

McFarlin made interesting observations on the distribution of known endemic species in the scrub habitat in Polk and adjacent counties, relatively little of which remains (Christman 1988). McFarlin's comments were prescient regarding this trend. For instance, he noted that the presence of Turkey Oak (*Quercus laevis*) was a general indication of land that was suitable for citrus, which is the crop that most frequently displaced scrub and sandhill habitat. Comparing his comments (McFarlin 1935) with those of present day observers helps us to understand how dramatic that change has been. McFarlin described the beargrass, *Nolina brittoniana*, as "our most common species inhabiting the scrub and inland sand dunes," the crucifer, *Warea amplexifolia*, as "locally abundant," the scrub plum, *Prunus geniculata* as "widespread," the morning-glory, *Bonamia grandiflora* as "frequent in the sandy soil of the scrub," and the milkweed, "*Asclepias curtissii*," as "frequent in scrub." Now they are rare and classified as endangered or threatened (Coile & Garland 2003; Wunderlin & Hansen 2000).

He left another legacy that was probably unintended. Although McFarlin recognized the problems of invasive exotic species—his manuscript mentions Ceasar Weed (*Urena lobata*), Australian Pine (*Casuarina esquisetifolia*) and others—he was responsible for some local introductions of other invasive plant species. Through his years in the nursery trade, McFarlin was responsible for the introduction of of the orchid tree, *Bauhinia variegata*, into Winter Haven (Burr 1974). This tree is classified as a Class I invasive species (Florida Exotic Pest Plant Council 2005). While operating the botanical garden at Highlands

Hammock, McFarlin was apparently responsible for the introduction of the Flax Lily (*Dianella caerulea*), which continues to be a management problem in the park today (A. Hine, pers comm.).

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Book Review

William S. Justice, C. Ritchie Bell, and Anne H. Lindsey. 2005. **Wild Flowers of North Carolina (Second Edition).** (ISBN 0-8078-5597-9, pbk.). University of North Carolina Press, P.O. Box 2288, Chapel Hill, NC 27515-2288, U.S.A. (**Orders:** www.uncpress.unc.edu/books/T-7662.html). $29.95, 376 pp., 553 color and 6 b&w illus., 6 tables, 1 chart, appendices, bibliography, index, 5 1/2" × 8 1/2".

Edition 2 supplants the original from 1968 by Justice and Bell—it includes 100 more species than the original and provides brief notes on toxicity and medicinal uses. With conservation and preservation first in mind, the authors note that "Our goal in this presentation of 500 native or naturalized plants in North Carolina is to open eyes, minds and hearts to the story of the state's wild flowers, their beauty, their interesting attributes, their uses, and, in many cases, their plight." Most pages include a photo and notes for each of two species, and Appendix 1 gives an outline of horticultural information for each species. The Edition 2 photos are better reproduced, often sharper, sometimes cropped differently, but usually reduced in size up to 30 percent. For Edition 3, better planning of layout surely could increase image sizes and decrease the large areas of white space on so many of the pages.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

FLORISTIC DIVERSITY AND COMPOSITION OF TERRA FIRME AND SEASONALLY INUNDATED PALM SWAMP FORESTS IN THE PALMA REAL WATERSHED IN LOWER MADRE DE DIOS, PERU

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ABSTRACT

We report the results of a tree species inventory of seven hectares of lowland subtropical moist forest in the Palma Real River watershed of lower Madre de Dios, Peru, where we discovered a type of palm swamp forest vegetation that has not previously been studied. The goal of the study was to investigate the forest vegetation of the Palma Real watershed with special emphasis on a comparison between the wetland forest vegetation and the surrounding terra firme forests. A total of 3534 trees ⩾10 cm DBH belonging to 442 species in 62 families were measured and identified in the seven plots. Three distinct forest types resulted from Principal Components Analysis (PCA) and WPGMA cluster analysis of both family and species abundance data, including two types of terra firme forests and a palm swamp forest. The five terra firme forest plots sampled, with a range of 104–138 species, were less diverse than other one-hectare forest plots reported from the region, which have a diversity ranging from 151–197 species. The two palm swamp forest plots, with 126 and 167 tree species, were more diverse than surrounding terra firme forest plots sampled in this study. One of the palm swamp forest plots was extremely diverse with 167 species, only seven species less than the average diversity across 14 one-hectare terra firme plots sampled by other investigators in Madre de Dios, Peru. Both palm swamp forest plots had a greater number of stems distributed across smaller size classes. Both Fabaceae and Arecaceae were the most important plant families across all plots. The Arecaceae contributed significantly to distinguishing the palm swamp forest plots, composing 16–25% of all stems compared to only 9% of the stems in terra firme plots of the region. This high abundance of the palm family is from where we derive the name we are applying to this wetland forest type in the Palma Real watershed. Using satellite imagery we illustrate the importance of the extent of these palm swamp forests throughout the region.

RESUMEN

Reportamos los resultados de un inventario floristico de siete hectáreas en un bosque subtropical húmedo en la cuenca de la quebrada Palma Real, en Madre de Dios, Perú. El objetivo de este estudio fue investigar la vegetación de la Quebrada Palma Real con especial énfasis en una comparación

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entre un tipo de vegetación de pantano con palmeras y la vegetación de terra firme circundante. En total de 3534 árboles mayores a 10 cm de diametro (DAP) pertenecientes a 442 especies en 62 familias fueron medidos e identificados en siete parcelas. Tres tipos de bosque resultaron de los análisis de componentes principales y análisis de agrupamiento WPGMA mediante datos de abundancia por familia y por especie en los dos tipos de vegetación. Las cinco parcelas muestreadas en terra firme, con un rango de 104–138 especies por parcela, fueron menos diversas que otras parcelas estudiadas en la región, las cuales tienen un rango de 151–197 especies. Las dos parcelas muestreadas en bosque pantanoso de palmeras, con 126 y 167 especies, fueron más diversas que las parcelas de terra firme circundantes. Una de las parcelas del bosque pantanoso de palmeras fue extremadamente diversa con 167 especies, solo siete especies menos que el promedio reportado para 14 otras parcelas estudiadas por otros investigadores en Madre de Dios. Ambas parcelas del bosque pantanoso con palmeras tuvieron una alta densidad de tallos distribuidos en las clases diamémetricas más pequeñas, lo cual podría ser una explicación de la alta diversidad de especies. Fabaceae y Arecaceae fueron las familias más importantes para todas las parcelas. Arecaceae contribuyó significativamente a distinguir el bosque pantanoso con palmeras, comprendiendo entre el 16–25% de todos los tallos, comparado con solo el 9% de tallos en bosque de terra firme de la region. Esta alta abundancia de palmeras determinó el nombre que nosotros aplicamos a este tipo de bosque muy húmedo en la cuenca de la Quebrada de Palma Real. Usando imágenes satelitales nosotros ilustramos la importancia por su extensión, de estos bosques pantanosos de palmeras en la región. Finalmente nosotros instamos a desarollar mas estudios de largo plazo sobre la diversidad y ecología en la región, con énfasis en la importancia de estos bosques de Palma Real en la extracción de castaña (*Bertholletia excelsa*, Lecythidaceae) y otros recursos para la región y sus moradores.

INTRODUCTION

A large forest plot network has accumulated in the last decade from the Amazonian region. The highest tree species diversity has been reported from the western Amazon where Gentry (1988) and Valencia et al. (1994) recorded 283 and 307 species respectively in one-hectare forest plots. Oliveira and Mori (1999) found 285 species per hectare on very poor soils and under reduced rainfall in central Amazonia, which is essentially the same species diversity as found by Gentry in western Amazonia. In an analysis of data from 97 existing one-hectare forest plots from the Amazon, including the Guiana Shield, Ter Steege et al. (2000) showed that in all regions terra firme forests harbor a greater number of tree species per unit than any other forest types. Patterns of high tree species diversity have been attributed to high rainfall and more nutrient-rich soils of the western Amazon (Gentry 1988).

Nebel et al. (2001) and Kvist and Nebel (2001) emphasize the importance of wetland forests to both the ecological diversity and resource use in the Peruvian Amazon. While many forest plot inventories in the Amazon have focused on the diversity of terra firme and floodplain forests, few studies in the region have dealt with wetland vegetation. For example, only two swamp forest plots from the Amazon were available for inclusion in the large studies by Ter Steege et al. (2000, 2003), but those were excluded from the final analyses and spatial modeling. There is clearly a lack of data from wetland habitats in the Amazon. This minimal coverage of wetland vegetation leads to a generalized view of the

complexity and diversity of these ecosystems, as discussed by Kalliola et al. (1991), who argue for more focused studies.

The Tambopata-Candamo region and Manú National Park are two well-studied protected areas of Madre de Dios, Peru, that hold world records in diversity of various organisms, such as birds, insects, and mammals. National reserves, such as Tambopata, allow for protection and sustained use of plant resources. The Palma Real watershed is inside the Tambopata National Reserve and the Bahuaje-Sonene National Park, where management plans are needed since plant and animal extraction is carried out by indigenous and local people. Yet, no floristic treatment exists for the region and only a few small areas are represented by checklists.

In the Palma Real watershed and the surrounding region, there exists a vast area of terra firme forest and patches of seasonally inundated swamp forests. This mosaic of forests extends from the Tambopata Reserved Zone of lower Madre de Dios, Peru, to the Pampas del Heath in the border region of Peru and Bolivia. The seasonally inundated forests of this region are characterized by a distinctive topography that consists of small raised islands separated by shallow water channels during the rainy season or heavy rains in the dry season, and they sit upon a deep, fine, heavy gray soil. Because of the abundance of palm species in our study area we refer to this wetland vegetation as palm swamp forest. We have reviewed available literature that relates to the diversity, ecology, and distribution of wetland vegetation in the area, and we have found no existing description of this specific wetland vegetation. The palm swamp forests of Palma Real are different in species and family diversity and composition than the palm swamp forest communities of the northern Peruvian Amazon described by Kalliola et al. (1991). Although Haase (1990) described palm swamp communities in northern Bolivia, there is no description that matches the palm swamp forests of the Palma Real watershed. Nor are these palm swamp forest communities covered by Beck (1984). The goal of this study was to investigate the forest vegetation of the Palma Real watershed in lower Madre de Dios, Peru, with special emphasis on a comparison between these palm swamp forests and the surrounding terra firme forest vegetation.

METHODS

Study Site

The study was conducted in the Palma Real watershed, a tributary of the Madre de Dios River, approximately 28 km to the southeast of Puerto Maldonado, the capital and the principal city of the Department of Madre de Dios, Peru (Fig. 1). Nested within the Tambopata-Candamo National Reserve and the Bahuaje-Sonene National Park, this area of lowland subtropical moist tropical forest (Foster et al. 1994) receives about 2208 mm of precipitation annually and the average temperature is 24°C (mean over 36 years). During the driest months, May to

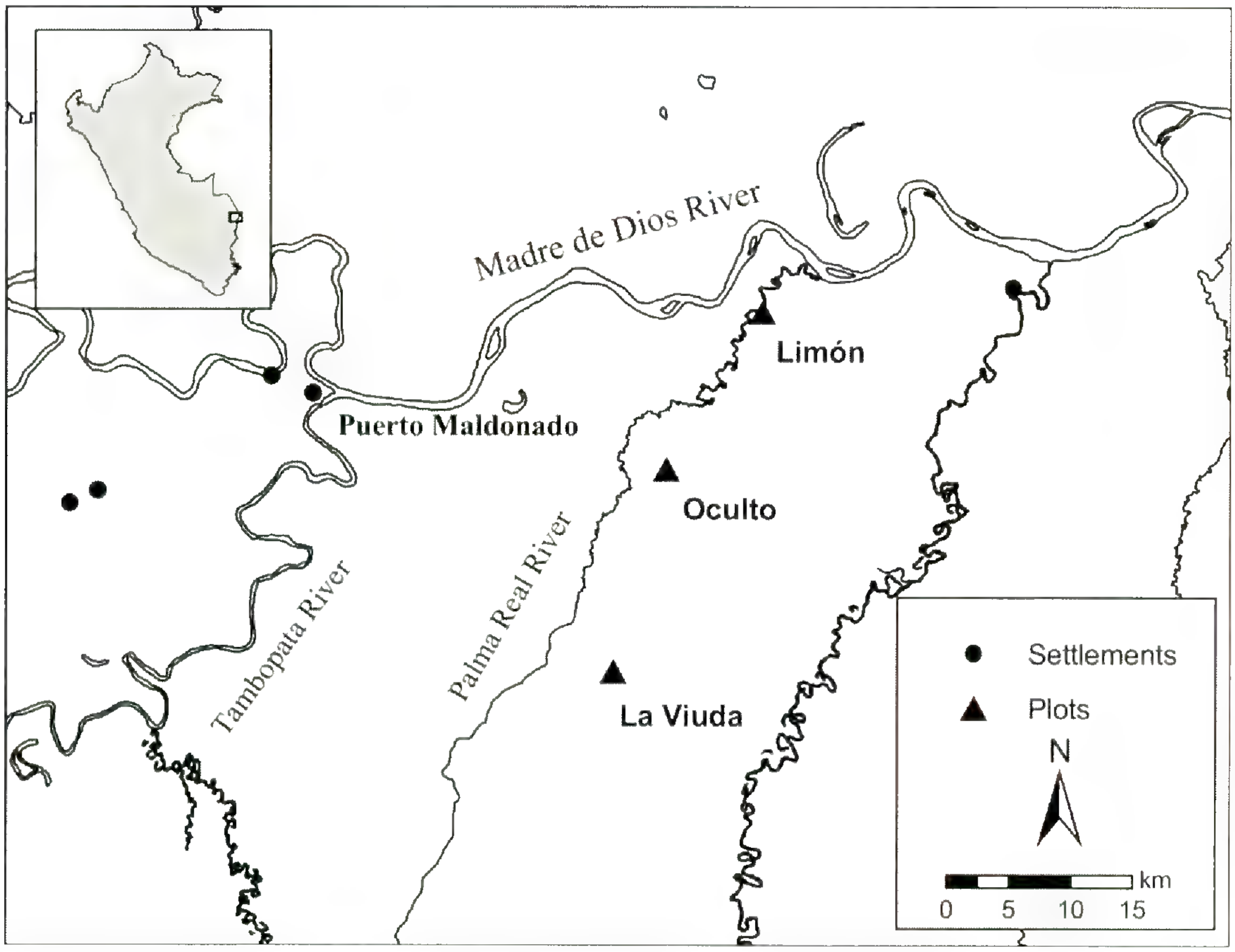


FIG. 1. Location of the three sites where forest plot studies were based, Limón, Oculto, and La Viuda.

September, the area receives occasional cold winds from the antarctic, which decreases daily temperatures to a minimum of 7–8°C, although this phenomenon of cold fronts, known as "friajes", lasts for only a few days at a time.

The general topography is flat, dissected by small streams, most of which are without water during the dry season. Three main types of habitats exist in the Palma Real watershed, forming an interesting mosaic of vegetation zones: (1) high terrace non-inundated forest (terra firme); (2) palm swamp forests - areas with poor drainage and seasonal inundation causing the formation of swamp-like forests; and (3) seasonally inundated floodplain forest. This study focused on terra firme and palm swamp forests, which are the most extensive forest types in the study area. The Brazil nut tree (*Bertholletia excelsa*, Lecythidaceae) is abundant in large areas of the terra firme forests in this region but it is absent from others. Seeds of the Brazil nut tree are extracted from the Palma Real watershed by harvesters (castañeros) every year during January–March, making this an economically important region in Madre de Dios, Peru. The forests of the Palma Real watershed maintain a healthy fauna with jaguars, ocelots, tapirs, peccaries, deer, and at least six species of monkeys. No logging activities have been conducted in this region since twenty years ago

when many Spanish Cedar trees (*Cedrela odorata*, Meliaceae) were extracted. Then terra firme forests of Palma Real that are characterized by high Brazil nut tree density have been divided by the Peruvian government into forest concessions of approximately 1000 hectares each and given to local extractors living in Puerto Maldonado.

Soils.—The soils of the terra firme forests are dominated by red clay and those of palm swamp forests by gray clay. Within the Palma Real zone, three representative sites were selected for quantitative studies of floristic diversity and composition (Figs. 1, 6): (1) Limón (12°32'19"S; 68°51'40"O), close to the Madre de Dios River; (2) Oculto (12°39'03"S; 68°55'40"O), in the middle of the zone; and (3) La Viuda (12°47'43"S; 68°58'07"O), to the extreme south of the zone.

Field Data

Seven permanent one-hectare forest plots were established in the Palma Real watershed, divided between Limón (3 plots), Oculto (3 plots) and La Viuda (1 plot). Within each site, one plot was established in terra firme (TF) forest with a known high density of 5–7 individuals of Brazil nut trees per hectare (Limón 1, Oculto 1, La Viuda 1). One plot in each of Oculto and Limón was established in TF forest with known absence of Brazil nut trees (Oculto 2 and Limón 2). In Oculto and Limón one plot was also established in palm swamp (PS) forest (Oculto 3 and Limón 3).

Each plot consisted of a square area of 100 × 100 m, divided into 25 subplots of 20 × 20 m. Each corner of the one-hectare forest plot is marked with a PVC stake labeled with the respective X,Y coordinate in red paint. All individuals, including palms, 10 cm or greater in diameter at breast height (DBH) were measured, mapped and identified to family, genus, and species or morphospecies when definite species determination was not possible. All individuals with multiple stems were considered as one individual, and the diameters of each stem were summed for basal area calculations.

Every species is represented by duplicate voucher specimen collections of one or more individuals. All identifications were made in the La Molina Herbarium (MOL) at the Agraria University in Lima, Peru, where duplicate voucher specimens were deposited. The Cronquist system of classification of flowering plants was used for the purposes of this project.

Data Analysis

Relative diversity, relative density, and relative dominance were calculated for each plot. The Importance Value Index (IVI) was calculated at the species and family level for each plot using the sum of the three measures, relative diversity, relative density, and relative dominance. Sørensen Similarity Index (Sørensen 1948) was calculated for all species found in the plots and for the 20 most abundant species. The Sørensen index is $2 * S_{12} / (S_1 + S_2)$, where S_{12} is the number of species common to both sites and S_1 and S_2 are the total number of species found

at site one and two. Plots were also grouped based on species and family abundance using Principal Components Analysis (PCA) and WPGMA cluster analysis (MVSP 3.12, Kovach Computing Services).

Comparing the raw number of species between plots without accounting for differences in stem density can give misleading results. To avoid this problem we used individual based rarefaction curves as suggested by Gotelli and Colwell (2001). Rarefaction curves were calculated using the software package EstimateS 7.5 (Colwell 2005).

RESULTS

Forest Structure

A total of 3534 trees ≥10 cm DBH belonging to 442 species in 62 families were measured and identified in the seven plots (Table 1). Three distinct forest types resulted from PCA: (1) palm swamp forest (Limón 3 and Oculto 3); (2) Limón terra firme forest (Limón 1 and Limón 2); and (3) Oculto/La Viuda terra firme forest (Oculto 1, Oculto 2 and La Viuda) (Figs. 2, 3). PCA resulted in almost no difference between the species (Fig. 2) and family level (Fig. 3), a pattern previously suggested by Terborgh and Andersen (1998).

Table 1 shows the principle structural characteristics for each plot. The palm swamp (PS) forests (PS) in both Limón and Oculto have a higher number of species than the terra firme (TF) forests at the same sites. Limón 3 has the highest number of individuals and species of all the plots while the two TF forest plots at Oculto are the least diverse. The rarefaction curves (Fig. 4) confirm these results and show that the higher diversity of the PS forest plots are not simply due to a higher stem density. The PS plots have a lower basal area than the TF plots (21.5 vs. 27.3). Distribution of trunk diameter classes shows the inverse J-shaped curve, with a mean proportion of 69% of individual trees found between 10 and 20 cm DBH.

Composition

Monimiaceae was the most abundant family in the TF forest plots, followed by Arecaceae and Fabaceae (Table 2). In PS forest plots Arecaceae and Fabaceae were the most abundant families. Looking at the 20 most abundant families (Table 2), Lauraceae, Moraceae, Violaceae, Lecythidaceae, Chrysobalanaceae, Sapotaceae, Burseraceae, and Cecropiaceae were found in both TF and PS forests, whereas Myristicaceae, Strelitziaceae, Linaceae, Bixaceae, Rubiaceae and Flacourtiaceae were found only in TF forests. Of the 20 most abundant families, Myrtaceae, Dichapetalaceae, Anacardiaceae, Clusiaceae, Ochnaceae, Sterculiaceae, and Combretaceae were restricted to the PS forests. The ten most abundant families represented 64% of all individual trees found. The most species-rich family across all plots was Fabaceae, followed by Lauraceae, Moraceae, Sapotaceae, Chrysobalanaceae, and Annonaceae. The ten richest families represented 54%

TABLE 1. Structural characteristics from 1 hectare plot.

	Limón 1	Limón 2	La Viuda	Oculto 1	Oculto 2	Oculto 3	Limón 3
No. of stems	499	532	473	422	508	492	608
No. of species	138	130	130	109	104	126	167
Basal area (m^2)	32.23	23.77	25.23	29.25	26.22	21.86	21.07
Categories by diameter (%)							
10–20 cm	63.4	70.5	69.5	64.9	65.9	74.6	74.5
20.1–40 cm	27.6	23.5	22.2	23.0	24.8	20.3	21.9
40.1–80 cm	7.4	5.1	7.0	10.2	8.3	4.3	3.5
> 80 cm	1.6	0.9	1.3	1.9	1.0	0.8	0.2
No. of species in 50% IVI	16	16	18	13	13	14	20
No. of families in 50% IVI	39	42	41	41	40	42	45

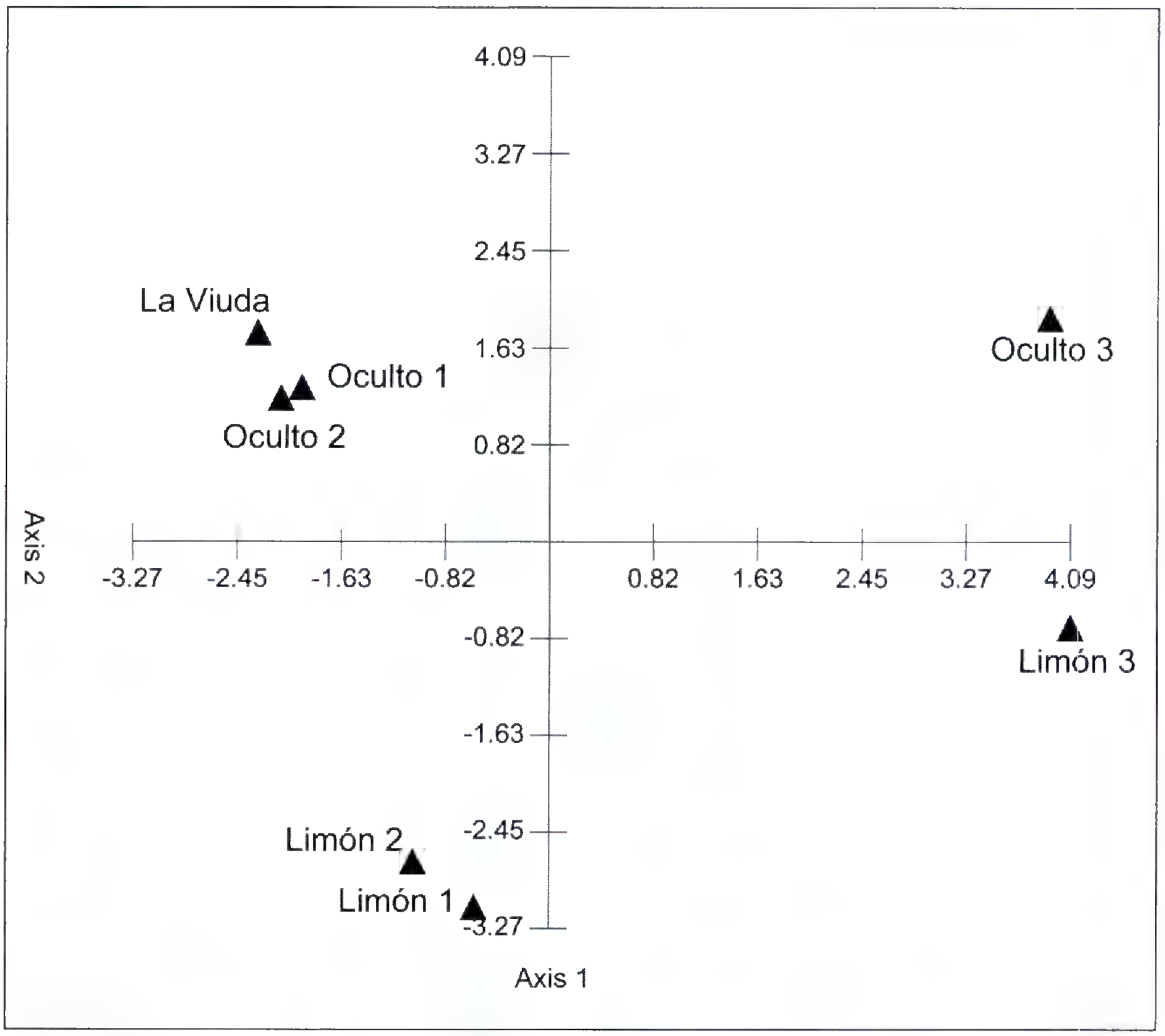


FIG. 2. Ordination of a Principal Component Analysis based on species abundance.

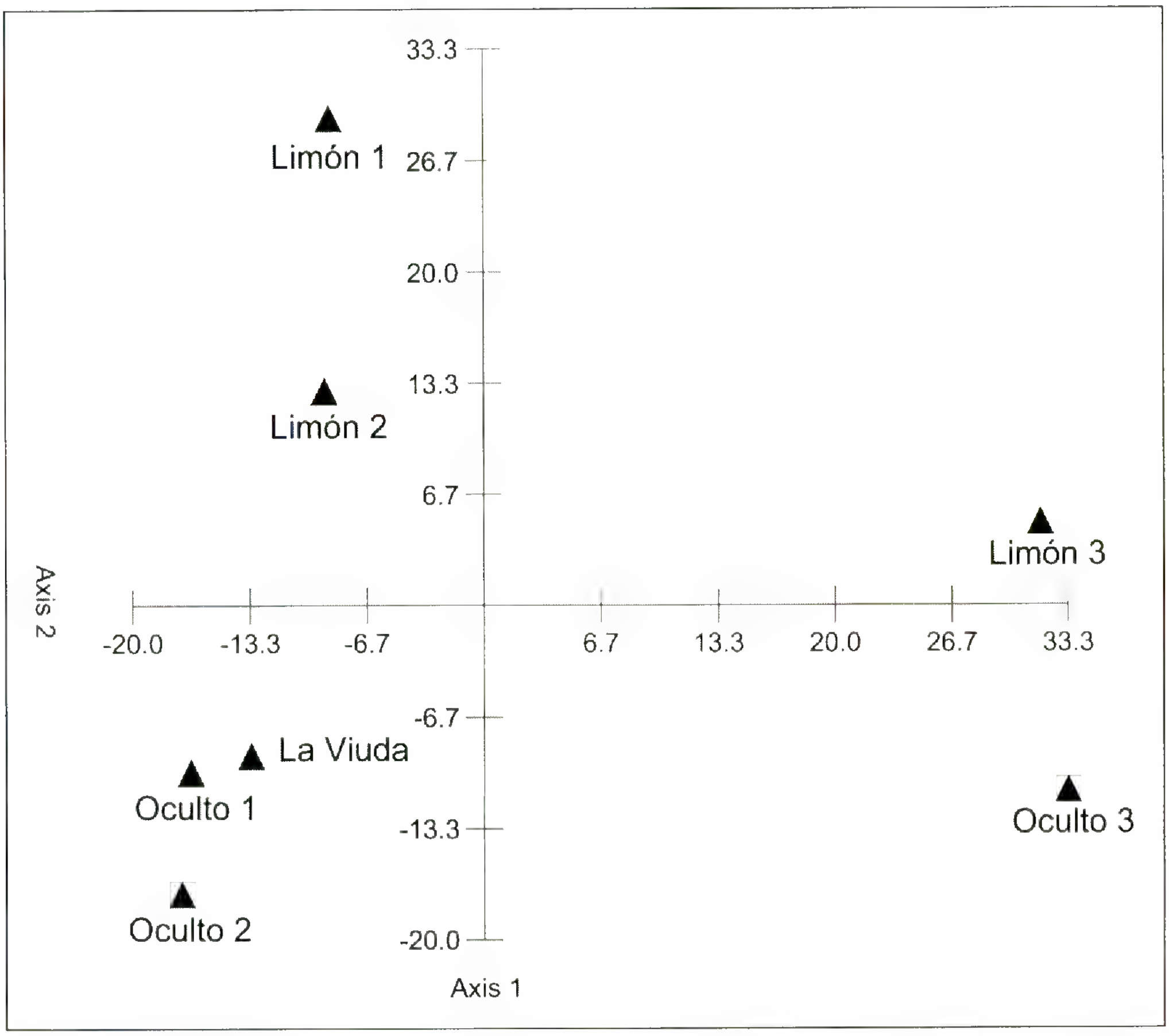


Fig. 3. Ordination of a Principal Component Analysis based on family abundance.

of all species. Table 3 summarizes the Importance Value Index (IVI) for the 20 most abundant families per plot, per forest type, and across all plots, emphasizing the importance of Arecaceae in PS forest plots, and the Fabaceae across all forest plots.

Table 4 lists the twenty most abundant species in each of the seven 1-ha forest plots. There were only seven species that occurred in all seven plots. Twenty species were found to occur in all five TF forest plots while 62 species were found to occur in both of the PS forest plots. A total of 243 species were found to occur in only one plot out of the seven. Out of the total of 442 species found across all the plots, 124 occurred only in the PS forest and 212 only in the TF forest. A total of 106 species were found to occur in both forest types. About 40% of the species were represented by only one individual and 65% by 1 to 3 individuals.

Similarity

Table 5 shows the Sørensen Similarity Index for all plots. Values range from 0.25 to 0.55 for all species and from 0.10 to 0.75 when only the 20 most abundant

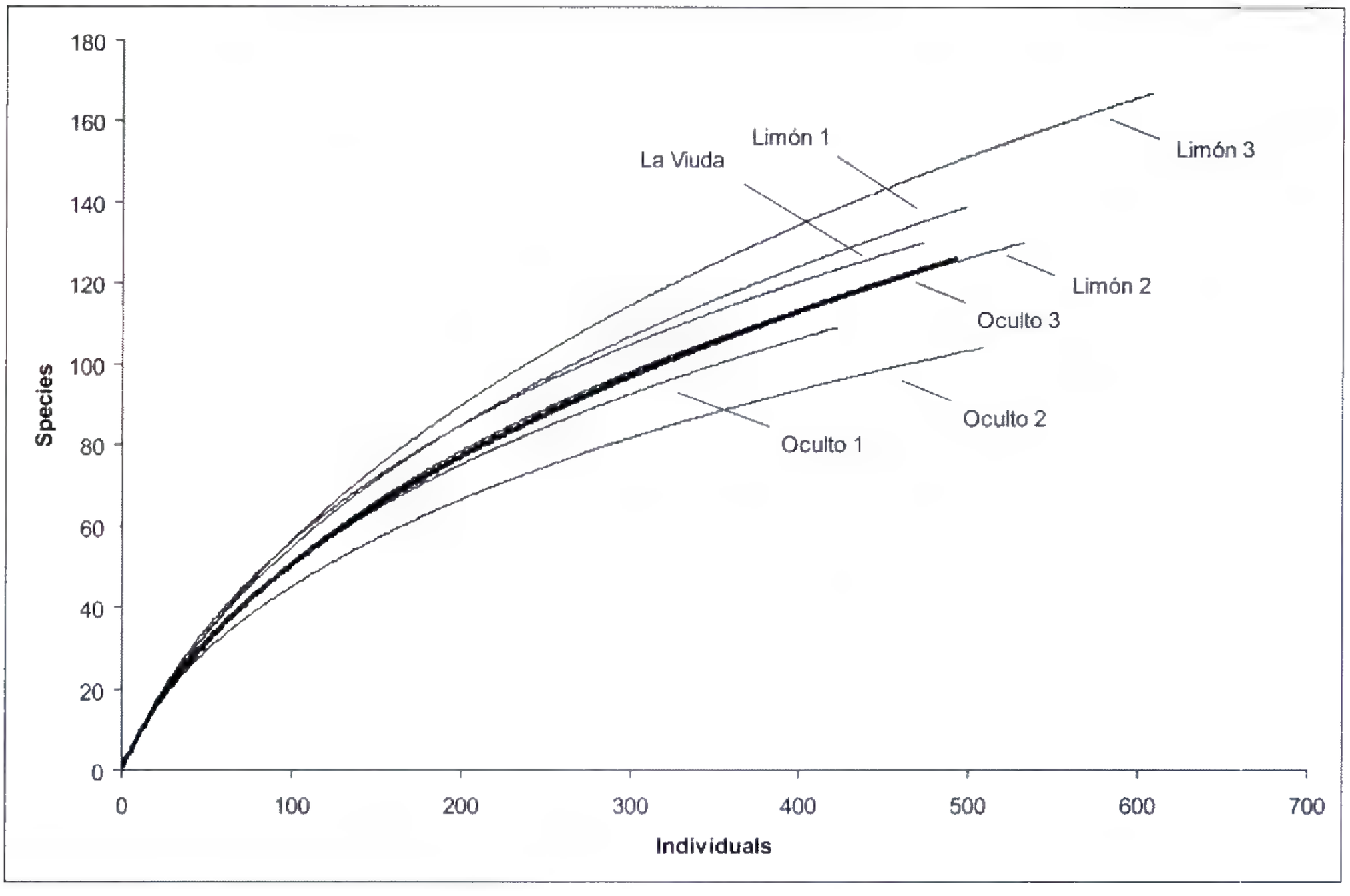


FIG. 4. Rarefaction curve showing relationship between number of individuals and number of species.

species were included. The 20 most abundant species, on average, represent 60% of all individuals (Range: 54–69%). Similarity analysis shows the same patterns already observed in the PCA. First, plots within the same forest type (TF or PS) are more similar to each other. Considering only the 20 most abundant species in each plot, this pattern becomes even more apparent. The TF forest plots from the same site (e.g., Oculto 1 and 2 or Limón 1 and 2) share a higher number of species with each other than they do with plots from different sites. Figure 5 provides the results of WPGMA cluster analysis based on species abundance, which shows that PS forest plots cluster together, as do TF forest plots from the same sites. When all species are considered, PS forests are more similar to the TF forest plots at the same site than to those farther away. However, this is not true when we consider only the 20 most abundant species. In this case, Limón 3 shares the same number of species with Limón 1 as it does with Oculto 2, and Oculto 3 and Oculto 1 are the least similar plots.

DISCUSSION

The Palma Real watershed presents a unique seasonally inundated PS forest habitat that is very different from the TF forests of the region. Based on species abundance, the two PS forest plots are clearly distinguished from the TF forest plots as shown by results of both PCA (Figs. 2, 3) and WPGMA cluster analysis (Fig. 5), as well as similarity index analysis (Table 5). *Euterpe precatoria* is the

TABLE 2. The 20 most diverse families in the two main forest types. Families in boldface are those that are among the top 20 in both forest types. Number of individuals are average by hectare.

Terra firme Forest			**palm swamp Forest**		
Family	**No. of individuals**	**No. of Species**	**Family**	**No. of individuals**	**No. of Species**
Fabaceae	41.6	39	Fabaceae	78	35
Lauraceae	30.6	26	Annonaceae	12	12
Moraceae	26.8	22	Chrysobalanaceae	18	12
Sapotaceae	9.6	17	Lauraceae	7.5	11
Chrysobalanaceae	7.6	14	Sapotaceae	16	11
Meliaceae	12.4	12	Moraceae	33.5	10
Annonaceae	9.4	11	Burseraceae	15.5	8
Cecropiaceae	20.2	10	Arecaceae	128.5	7
Monimiaceae	53	9	Apocynaceae	10.5	7
Flacourtaceae	6	9	Anacardiaceae	11.5	6
Apocynaceae	7.8	7	Lecythidaceae	24	7
Arecaceae	52.8	6	Clusiaceae	10.5	4
Burseraceae	19.8	6	Myrtaceae	15	4
Myristicaceae	36.8	5	Cecropiaceae	7.5	3
Rubiaceae	7.2	4	Meliaceae	8	3
Lecythidaceae	12.4	4	Dichapetalaceae	11.5	2
Violaceae	26.6	2	Violaceae	28.5	2
Linaceae	9.4	2	Ochnaceae	10.5	2
Strelitziaceae	14.2	1	Combretaceae	8	2
Bixaceae	9	1	Sterculiaceae	10	2

most abundant species in PS forest plots, Limón 3 and Oculto 3, contributing significantly to the major differentiation between the PS and TF forest plots. *Astrocaryum murumuru*, *Attalea butyracea*, *Brosimum laevis*, *Chimarrhis sp. 1*, *Dipteryx micrantha*, *Eriotheca globosa*, *Manilkara bidentata*, *Ouratea weberbaueri*, *Rheedia sp. 2*, *Terminalia oblonga*, and *Triplaris americana* are restricted to PS forest plots. *Calyptranthes bipenis*, *Iryanthera juruensis*, Lauraceae sp. 1, Lauraceae sp. 2, *Pourouma minor*, and Rubiaceae sp. 2 are restricted to TF forest plots. Based on our results, there are two groups of TF forest plots as demonstrated by Figures 2, 3, and 5. The first group of TF forest plots, Limón 1 and Limón 2, is distinguished primarily by the abundance of *Brosimum alicastrum*, *Pseudolmedia laevigata*, and *Rinoreocarpus ulei*, and secondarily by *Phenakospermum guyanense*. The second group of TF forest plots, Oculto 1, Oculto 2, and La Viuda, is distinguished by the abundance of *Minquartia guianensis*, *Oenocarpus batua*, *Roucheria punctata*, *Roucheria* sp. 1, Rubiaceae sp. 1, *Socrotea exorrhiza*, and *Tontolea corymbosa*.

Analysis of family abundance demonstrates similar results (Fig. 3, Table 3). The families Fabaceae and Arecaceae are the most abundant families across

TABLE 3. Family Importance Value (FIV) of the 20 most abundant families for each plot, botn forest types, and across all plots (sorted by Total column). The FIV was calculated as the sum of relative diversity, relative density, and relative dominance.

Family	LaViuda1	Limón1	Limón2	Limón3	Oculto1	Oculto2	Oculto3	PS	TF	Total
Fabaceae	35.39	33.25	42.05	52.04	25.96	29.65	47.27	48.96	33.55	37.28
Arecaceae	16.76	14.46	17.85	31.91	18.65	22.38	48.26	38.36	16.34	22.32
Moraceae	13.14	36.99	39.55	25.83	9.18	3.01	27.71	27.37	20.48	21.30
Lecythidaceae	20.45	30.71	4.90	17.16	37.98	17.41	9.49	13.45	22.05	20.11
Lauraceae	22.78	21.32	15.84	5.20	23.29	26.39	6.84	6.95	22.39	19.16
Monimiaceae	17.35	13.40	19.64	1.62	20.63	16.20	4.26	3.25	17.65	13.28
Sapotaceae	9.24	12.75	7.45	14.36	8.00	10.78	7.61	11.59	10.56	11.31
Burseraceae	6.26	8.81	10.92	11.01	12.86	15.82	4.53	8.10	10.36	9.52
Myristicaceae	12.42	9.69	6.69	4.46	12.80	24.57	1.41	3.13	12.01	9.17
Cecropiaceae	8.40	11.79	16.22	3.62	9.31	17.03	4.25	3.51	11.63	9.07
Chrysobalanaceae	5.80	5.51	6.06	10.40	9.63	5.73	14.52	12.06	7.26	8.69
Violaceae	2.58	22.93	12.96	13.98	3.11	2.40	4.48	9.40	8.59	8.52
Annonaceae	8.25	5.53	6.62	5.36	4.40	9.50	12.22	8.48	6.96	7.31
Apocynaceae	9.99	8.15	6.98	7.73	6.17	5.81	7.21	7.27	7.20	6.88
Meliaceae	3.40	7.50	14.20	2.41	8.27	9.74	5.59	3.43	8.50	6.74
Euphorbiaceae	5.77	4.33	1.07	5.79	6.56	8.51	3.20	3.89	6.40	5.69
Flacourtiaceae	10.37	0.97	7.12	5.91	7.30	5.65	1.08	3.85	5.92	5.68
Anacardiaceae	2.11	4.99	4.77	5.61	5.23	4.50	8.75	7.25	4.60	5.25
Clusiaceae	6.18	3.71	3.71	5.66	2.90	3.29	3.62	4.43	4.36	4.61

all PS and TF forest plots, although they are more abundant in PS forest plots. The Lauraceae and Monimiaceae are more abundant in TF forest plots. The Violaceae and Moraceae are much more abundant in all the Limón plots including the PS forest plot Limón 3, distinguishing all the Limón plots from the other plots on axis 1 in the PCA (Fig. 3). The Dichapetalaceae and Polygonaceae are found only in PS forest plots, helping to distinguish them from TF forest plots. A higher abundance of the Bombacaceae in PS forest plots also helps to distinguish them from the TF forest plots. The first TF forest plot group of Limón 1 and 2 is distinguished by a higher abundance of Lauraceae species than the rest of the plots, as well as by the Staphylaceae, which only occurs in Limón 1 and 2 TF forest plots. The second TF forest plot group of Oculto 1 and 2 and La Viuda is distinguished by a high abundance of Myristicaceae, as well as by the Bixaceae, Hippocrateaceae, and Linaceae, which only occur in those plots.

PS forest plots of Palma Real have a higher abundance of palms in comparison to the TF forest plots, making the Arecaceae one of the most significant families distinguishing the different forest types (Table 2 & 3). This is especially apparent in Oculto 3, where palms account for the top three and sixth most abundant species sampled. Palms compose 25% of the stems in Oculto 3 and 16% in Limón 3. In comparison, in all TF forest plots in the region palms make up only 9% of all stems. *Euterpe precatoria*, the most common palm in the area,

TABLE 4. The twenty most abundant species in each of the seven one-hectare forest plots.

LaViuda1		Oculto1		Oculto2		Limón1	
Bixa arborea	32	Siparuna decipiens	31	Iryanthera laevis	50	Leonia glycicarpa	40
Siparuna sp. 1	30	Siparuna sp. 1	28	Siparuna sp. 1	35	Rinoreocarpus ulei	40
Siparuna decipiens	19	Euterpe precatoria	27	Iryanthera juruensis	30	Euterpe precatoria	27
Tachigali chrysophylla	17	Iryanthera laevis	19	Euterpe precatoria	29	Siparuna decipiens	23
Oenocarpus bataua	15	Lauraceae sp. 1	16	Tachigali chrysophylla	21	Iryanthera juruensis	20
Socrotea exorrh'za	15	Ouratea sp. 1	16	Lauraceae sp. 1	20	Lauraceae sp. 1	15
Euterpe precatoria	14	Oenocarpus bataua	14	Oenocarpus bataua	18	Pseudolmedia laevis	15
Lauraceae sp. 1	14	Protium sp. 2	12	Pourouma minor	18	Siparuna sp. 1	15
Roucheria punctata	12	Tetragastris panamensis	12	Eschweilera coriacea	17	Brosimum alicastrum	10
Iryanthera juruensis	11	Iryanthera juruensis	10	Phenakospermum guyanense	17	Lauraceae sp. 2	10
Tachigali polyphylla	10	Roucheria punctata	10	Protium sp. 2	17	Guarea macrophylla	7
Calypthrantes bipenis	9	Tachigali polyphylla	10	Socrotea exorrhiza	13	Inga auristillae	7
Tetragastris panamensis	9	Tontolea corymbosa	9	Bixa arborea	12	Lauraceae sp. 9	7
Iryanthera laevis	8	Hirtella glandistipula	8	Siparuna decipiens	10	Pseudolmedia laevigata	7
Melastomataceae sp. 1	7	Bertholletia excelsa	7	Tetragastris panamensis	9	Socrotea exorrhiza	7
Phenakospermum guyanense	7	Pourouma minor	7	Tontolea corymbosa	9	Tetragastris panamensis	7
Pourouma minor	7	Trichilia quadrijuga	7	Ouratea sp. 1	8	Turpinia sp. 1	7
Rubiaceae sp. 2	7	Phenakospermum guyanense	6	Lacistema aggregatum	7	Castilla ulei	6
Inga gereauana	6	Hebepetalum humirifolium	6	Roucheria punctata	6	Celtis schippii	6

TABLE 4 (continued from left)

Limón2		Limón3		Oculto3	
Euterpe precatoria	55	Euterpe precatoria	88	Euterpe precatoria	61
Siparuna decipiens	38	Leonia glycicarpa	32	Socrotea exorrhiza	32
Phenakospermum guyanense	36	Calypthranthes densiflora	26	Astrocaryum murumuru	31
Rinoreocarpus ulei	27	Eschweilera coriacea	26	Tachigali chrysophylla	25
Siparuna sp. 1	25	Tachigali chrysophylla	23	Theobroma subincanum	16
Tetragastris panamensis	22	Socrotea exorrhiza	15	Attalea butyracea	13
Brosimum alicastrum	13	Rinoreocarpus ulei	13	Tapura tessmannii	13
Iryanthera juruensis	12	Ouratea cf. weberbaueri	12	Terminalia oblonga	13
Leonia glycicarpa	12	Tetragastris panamensis	12	Eschweilera coriacea	12
Tachigali sp. 1	11	Neea sp. 8	10	Leonia glycicarpa	12
Pourouma guianensis	10	Brosimun lactescens	9	Brosimun lactescens	11
Lauraceae sp. 1	8	Manilkara bidentata	9	Hirtella excelsa	10
Pourouma minor	8	Tapura tessmannii	9	Triplaris americana	10
Cecropia sciadophylla	7	Inga edulis	8	Dipteryx micrantha	9
Eschweilera coriacea	7	Tachigali polyphylla	8	Tapirira guianensis	8
Pseudolmedia laevigata	7	Aspidosperma vargasii	7	Brosimun guianensis	6
Tachigali sp. 2	7	Chimarrhis sp. 1	7	Cecropia sciadophylla	6
Aspidosperma vargasii	6	Pseudolmedia macrophyla	7	Cordia cf. scabrifolia	6
Geissospermum reticulatum	6	Rheedia sp. 2	7	Inga gereauana	6

TABLE 5. Number of common species (above) and Sørensen Similarity Index (below) by one-hectare plot. The diagonal shows the total number of species for each plot. All species / 20 most abundant species.

	La Viuda	Limón 1	Limón 2	Limón 3	Oculto 1	Oculto 2	Oculto 3
La Viuda	**130**	51 / 8	56 / 10	43 / 5	55 / 13	46 / 13	32 / 4
Limón 1	0.38 / 0.40	**138**	61 / 10	56 / 5	49 / 7	49 / 8	36 / 3
Limón 2	0.43 / 0.50	0.45 / 0.50	**130**	50 / 7	48 / 10	52 / 10	32 / 5
Limón 3	0.29 / 0.25	0.37 / 0.25	0.34 / 0.35	**167**	40 / 4	44 / 5	64 / 8
Oculto 1	0.46 / 0.65	0.40 / 0.35	0.40 / 0.50	0.29 / 0.20	**109**	59 / 15	34 / 2
Oculto 2	0.39 / 0.65	0.40 / 0.40	0.44 / 0.50	0.32 / 0.25	0.55 / 0.75	**104**	33 / 4
Oculto 3	0.25 / 0.20	0.27 / 0.15	0.25 / 0.25	0.44 / 0.40	0.29 / 0.10	0.29 / 0.20	**126**

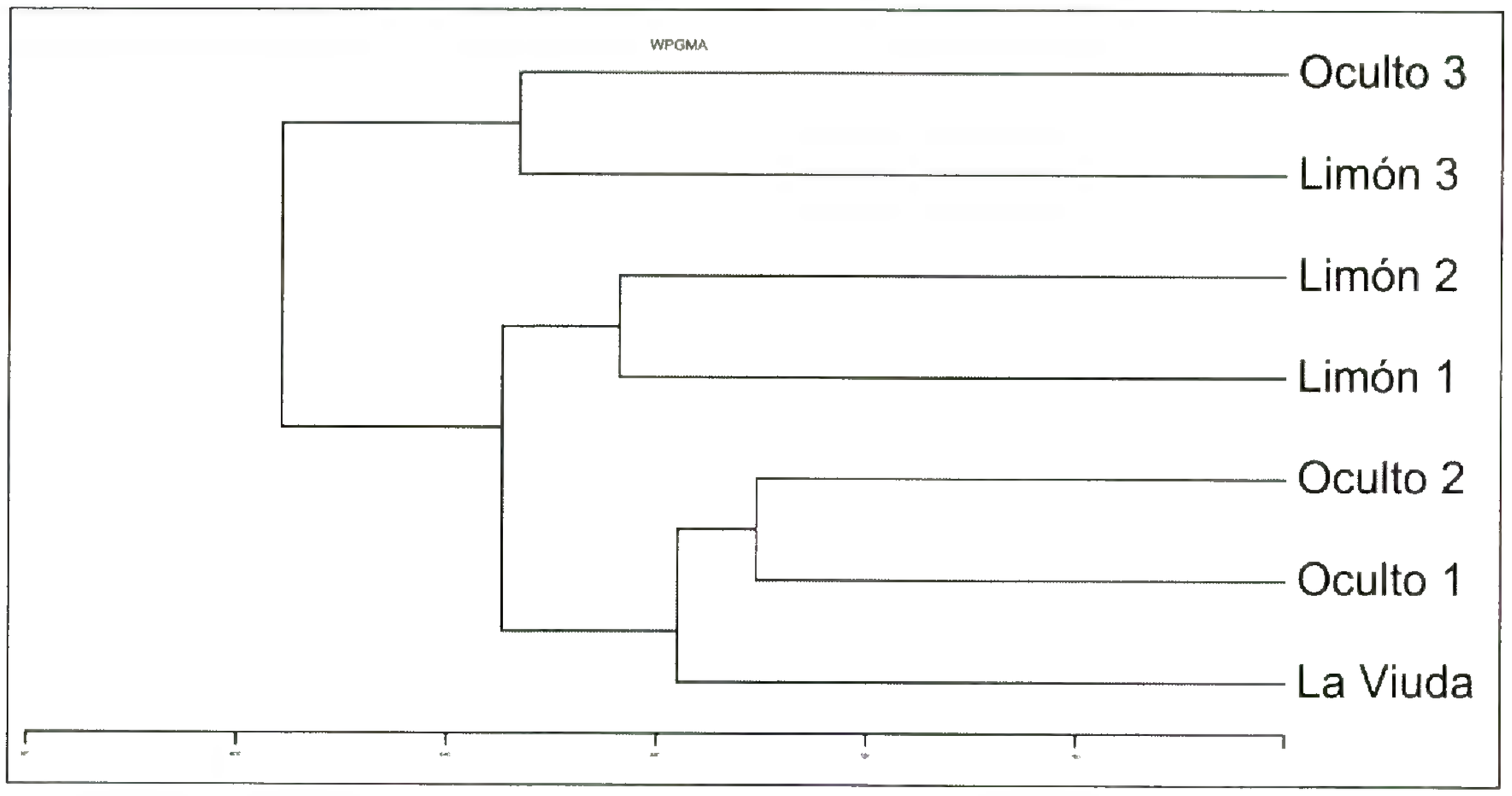


FIG. 5. Dendrogram of WPGMA cluster analysis based on family and species abundance.

is among the five most abundant species in six of the one-hectare forest plots and it is the most abundant species sampled in both of the PS forest plots, with 88 stems in Limón 3 and 61 stems in Oculto 3. *Socrotea exorrhiza* is also an important species in PS forest plots, ranking as the sixth most abundant species in Limón 3 with 15 stems, and the second most abundant species in Oculto 3, with 32 stems. *Astrocaryum murumuru* is the third most abundant species in Oculto 3, with 31 stems. In Oculto 3, *Attalea butyracea*, known locally as "shebon", is the sixth most abundant species, from which has come the local common name of this forest type, *shebonal*, but this is not true for Limón 3.

One of the most important families in the TF forest plots was the Monimiaceae (Figs. 2, 3), making this the first report of high abundance and dominance of this family in any tropical forest plot study. This family was rep-

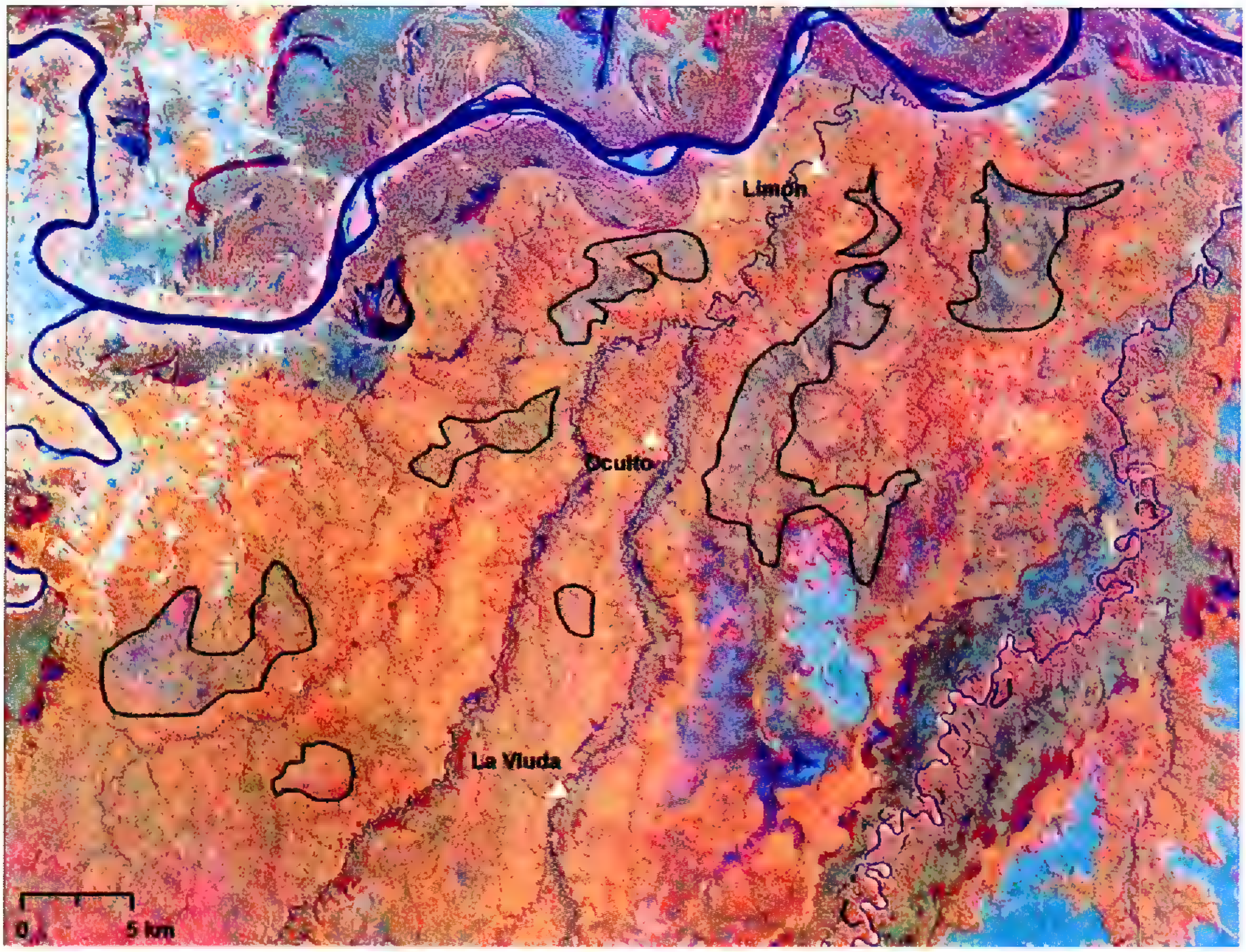


FIG. 6. Landsat TM satellite image from July 2001 showing the three field sites, Limón, Oculto, and La Viuda, and the distribution and extent of palm swamp forests in the region. Bright blue areas to the right are the Pampas del Heath on the border of Peru and Bolivia.

resented by two species of the genus *Siparuna* that were common in areas of tree fall gaps. The presence and abundance of *Tachigali* sp., a monocarpic species of the Palma Real watershed, might explain the presence of tree fall gaps and existence of several groups of light-demanding species (e.g., Brazil nut and Cecropiaceae).

We found that the PS forest plots differ structurally from other forests by a greater number of stems, the distribution of tree diameter size, and basal area, especially the site Limón 3, which has 80 more stems than other plots (Table 1). In contrast, the TF forest plots in the Palma Real watershed present the typical structure in comparison to reports from other regions in Madre de Dios, and the Amazon basin, in general (Pitman et al. 2001).

The PS forests of the Palm Real watershed are characterized by several months of anaerobic conditions because of the inundation of the area during the rainy season from at least November to February. As suggested by Terborgh and Andresen (1998) and Connell and Lowman (1989), who note that swamp forests are characterized by low tree diversity and high dominance by one or a

low number of species, we expected to find a relatively low species diversity in the PS forests of the Palm Real watershed. However, the most significant result of this study was that the PS forests in the Palma Real watershed were found to have a higher tree species diversity per unit area than TF forests of the region. Limón 3, a PS forest plot, was the most diverse of all plots sampled, with 167 tree species, only seven species less than the average diversity of 175 species across 14 one-hectare TF forest plots sampled in Madre de Dios, Peru, by Pitman et al. (2001). Although Oculto 3 was not as diverse as Limón 3, with 126 species it had more or just slightly fewer species than the TF forest plots sampled, and it was more diverse than the two neighboring TF forest plots from the same site (Oculto 1 and 2). All of our TF forest plots from the Palma Real watershed were less diverse than TF forest plots sampled in the neighboring Tambopata region, which range between 151 and 197 species (Gentry 1988; Phillips et al. 2003).

It is interesting to compare the diversity of the two PS forest plots of the Palma Real watershed with other one-hectare swamp forest plots in the Madre de Dios region. Pitman et al. (1999) and Terborgh and Nuñez (unpublished data) have found a range of 61–129 tree species among five one-hectare plots in Madre de Dios, Peru. Phillips et al. (2003) report 158 tree species from a swamp forest plot in the Tambopata region. The Oculto 3 PS forest plot from Palma Real falls out at the upper limit of the first range, with 126 species total. Limón 3, with 167 species, appears to be the most diverse swamp forest plot discovered to date in Madre de Dios, Peru. And, as mentioned, Limón 3 is nearly as diverse or is more diverse than many non-wetland TF and floodplain forest plots in Madre de Dios, Peru.

Our results and discoveries lead us to some important questions about the forests of the Palma Real watershed and argue for continued studies of this region. First of all, why are the PS forest plots of Palma Real so high in diversity in comparison to plots in neighboring non-swamp forest plots? And second, why are the TF forest plots relatively low in diversity compared to the PS forest plots of the Palma Real watershed, especially Limón 3, and other TF forest plots from the Tambopata region and Madre de Dios, Peru, in general?

The importance of the PS forest in the region can be seen in the Landsat satellite image (Fig. 6), which shows the great expanse of these forests across the landscape from the Tambopata River in Peru to the Heath River on the Bolivian-Peruvian border and beyond to the east into Bolivia. Preliminary studies in the La Torre River watershed (Cornejo, unpublished data) show a forest with the same characteristics of the PS forests of the Palma Real watershed, with a dominance in the understory of *Lycopodium* sp., *Selaginella* sp., *Clusia* spp., Melastomataceae spp., and other species of non-woody plants that were not sampled in our forest plots. Interestingly, such plants are also found in the vast wetland savannahs to the east, known as the Pampas del Heath along the border of Peru and Bolivia. Local people in the region, in passing conversations with

our team, have mentioned that the Pampas del Heath wetland savannahs can develop into dense swamp forests, especially in the absence of management by fire. We hypothesize that these diverse PS forests may represent a successional stage of vegetation derived from the Pampas del Heath savannahs that are more common to the east. This hypothesis could be tested using a combination of remote sensing and intensive ground-truthing between the Tambopata region and the Pampas del Heath savannahs to the east. The Pampas del Heath sits on a thick mass of organic matter that has accumulated over hundreds of years of deposition and slow decomposition characteristic of wetland ecosystems (i.e., bogs). In other words, perhaps the scattered PS forests of the Palma Real watershed and surrounding region represent a preliminary stage of succession from open wetland savannah to tropical forest. Pollen cores could shed some light on the succession of these vegetation types.

This leads us to our second open-ended question, which is why are the TF forest plots of the Palma Real relatively low in diversity? The forests of Madre de Dios, Peru, are referred to as subtropical moist tropical forests (Foster et al. 1994). It is possible that the forests in the Palma Real watershed receive less precipitation than forests to the west, from Tambopata to Manu, in Madre de Dios, Peru. However, there are no climate data available to test this hypothesis. Another possibility is that the soils of TF forests in the Palma Real region are nutrient-poor. We do not have data that enable us to test this hypothesis. We recommend future soil sampling in association with vegetation studies in the Palma Real region.

It is possible that with continued sampling of PS and TF forests in the Palma Real watershed, other patterns of plot diversity will be discovered, including more diverse TF forests and differences in PS forest diversity. Clearly, more studies are needed of PS and TF forests of the Palma Real watershed. Considering that the Palma Real watershed is one of the most important zones of Brazil nut extraction in all of the southwestern Amazon, we conclude by arguing for more sustained and long-term studies of the botanical and ecological diversity, and the conservation and management of this region.

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Book Review

Campbell and Lynn Loughmiller. Updated by Damon E. Waitt. 2006. **Texas Wildflowers: A Field Guide (Revised Edition).** (ISBN 0-292-71286-3, pbk.). University of Texas Press, P.O. Box 7819, Austin, TX 78713-7819, U.S.A. (**Orders:** http://www.utexas.edu/utpress, 512-471-4032). $19.95, 278 pp., 381 color photo, 4 1/2" × 7 1/4".

This is the successor to the original from 1984, which, as the introduction notes, has been among the top three best sellers for the University of Texas Press, with more than 155,000 copies sold. The new edition includes an additional 61 species (for a total of 370), but most of the photos have been replaced. Original text is mostly unchanged. The family order is rearranged (alphabetical, consistently using "-aceae" endings for the names) and scientific nomenclature is updated for species names, about 20 percent of which have been supplanted or modified since 1984. Dr. Damon Waitt of the Wildflower Center in Austin has been responsible for the taxonomic revision and accuracy of the photo identifications, as both of the Loughmillers have passed on.

In explanation of why Edition 2 "departs so radically in appearance from the first," the introduction notes that the cover stock is more durable and the book narrower—changes that are "part of the University of Texas Press plan to develop a complete series of natural history field guides." Apparently as part of the same revamp, margins are justified, spaces expanded between the words and lines, and the font less bold—resulting in considerably less compact text. The new photos are considerably smaller and seem subsidiary to the text. Edition 2 is useful, but if you don't have the first, try to find a copy of it also, since the original Loughmiller photos, in addition to their larger size, often show views more representative of the species, and a brief statement for each one notes where it was taken (e.g., "Photographed near Blanco State Park in April;" "Photographed in the Big Thicket in May").—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

A VASCULAR PLANT INVENTORY OF STARKEY WILDERNESS PRESERVE, PASCO COUNTY, FLORIDA

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ABSTRACT

Starkey Wilderness Preserve, owned and managed by the Southwest Florida Water Management District, contains 7,739.5 hectares with 18 plant communities. A floristic inventory was conducted on 449.2 hectares within the property which consists of 11 community types and is considered as representative of the entire Preserve. The objective of this study, conducted from May 2003 to October 2004, was to compile a list of the vascular plant taxa found to be used by the Southwest Florida Water Management District to help in their management regimes. A total of 483 taxa were collected, representing 104 families, and 271 genera. Of these, 444 are native taxa, 16 Florida endemic taxa, 39 non-native taxa, 12 endangered, threatened or commercially exploited taxa, and 33 county records. Each plant community is described and an annotated list of the vascular plant taxa is presented.

RESUMEN

La reserva de Starkey Wilderness, gestionada por el Southwest Florida Water Management District, tiene 7,739.5 hectáreas con 18 comunidades vegetales. Se realizó un inventario florístico en 449.2 hectáreas de la reserva que contiene 11 tipos de comunidades y que se consideran representativos de la Reserva entera. El objetivo de este estudio, realizado desde mayo de 2003 hasta octubre de 2004, fue compilar una lista de taxa de plantas vasculares usadas por el Southwest Florida Water Management District para ayudar en su régimen de gestión. Se colectaron un total de 483 taxa, que representan 104 familias, y 271 géneros. De ellos, 444 son taxa nativos, 16 taxa endémicos de Florida, 39 taxa alóctonos, 12 taxa en peligro, amenazados o explotados comercialmente, y 33 citas del condado. Se describen las comunidades vegetales y se presenta una lista comentada de los taxa de plantas vasculares.

INTRODUCTION

Florida is a unique state with a relatively flat topography and generally fast draining soils. These conditions would presumably lead to a flora with low diversity, but that is not the case. The state is about 1000 km long and spans about 6.5° latitude resulting in a diverse flora consisting of nearly 4,200 taxa of native and naturalized non-native vascular species (Wunderlin & Hansen 2003), the third most diverse in the United States. As Florida is also the fourth most populated state, it is important to work to conserve and protect the state's flora.

Several agencies in Florida work to secure large tracts of land in an effort to prevent development and to establish areas of conservation. One of these, the Southwest Florida Water Management District (SWFWMD), owns many parcels of land for a variety of water management practices including the protection

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and development of potable water supplies, aquifer recharge, water quality enhancement, restoration and protection of natural systems, and structural flood control. The property in which the inventory was conducted is owned and managed by SWFWMD. The results of this research are intended to help SWFWMD make knowledge-based management plans for its property.

Site Overview

Physical Location.—Starkey Wilderness Preserve is located in southwestern Pasco County, Florida, near the west coast of central Florida (Fig. 1). It is 6.4 km northeast of Seven Springs and 4.4 km northwest of Odessa. Main access to the Preserve is Wilderness Road approximately 5.6 km from State Road 54. A portion considered to represent the major habitats found within the entire Preserve was selected for this inventory. The Starkey Wilderness Preserve is included within Sections 1–17, 21–24, and 26–27, Township 26 South, Range 17 East and Sections 10–11, 13–15, 22–27, and 33–36, Township 25 South, Range 17 East. The entire Preserve comprises approximately 7,739.5 hectares and consists of 18 plant communities. Of these, 11 occur within the study site. The study site, consisting of 449.2 hectares, includes portions of Sections 3–4, 8–10, and 15–17, Township 26 South, Range 17 East. The boundaries of the study site comprise a power line artery along the western edge, a paved biking trail at the north, an unpaved road running due south along the eastern edge, and the Anclote River along the south.

Early Inhabitants.—The first humans who lived near the Starkey Wilderness Preserve were the Safety Harbor Culture or the Tocobaga, who inhabited the Florida Gulf coast (Lawson et al. 1981). The period of their inhabitance was from 900 A.D. through the early eighteenth century (Milanich 1994). The settlement area extended from the Withlacoochee River (north and east boundary of Citrus County) south to the Charlotte Harbor area (Charlotte County). Tocobaga arrowheads have been unearthed on the Starkey property, suggesting their use of the land to hunt (Lawson et al. 1981). Approximately 33 prehistoric archaeological sites have been identified as temporary campsites for hunting within the Starkey Wilderness Preserve (SWFWMD 1990). Hunters on the Preserve could have originated from two different sites. The first, a flint workshop located 3.2 km north of the Anclote River along the coast; and the second, Tarpon Springs at the mouth of the Anclote River (Willey 1949). In the eighteenth century, after the Spanish established themselves in much of the state, the remaining Tocobaga are believed to have joined the Creek tribes from further north as they moved south seeking refuge from persecution by the new settlers.

The land now included in the Starkey Wilderness Preserve passed from the Federal Government to the State of Florida and private ownership beginning in 1856 (Lawson et al. 1981). Principal land uses were for turpentine production

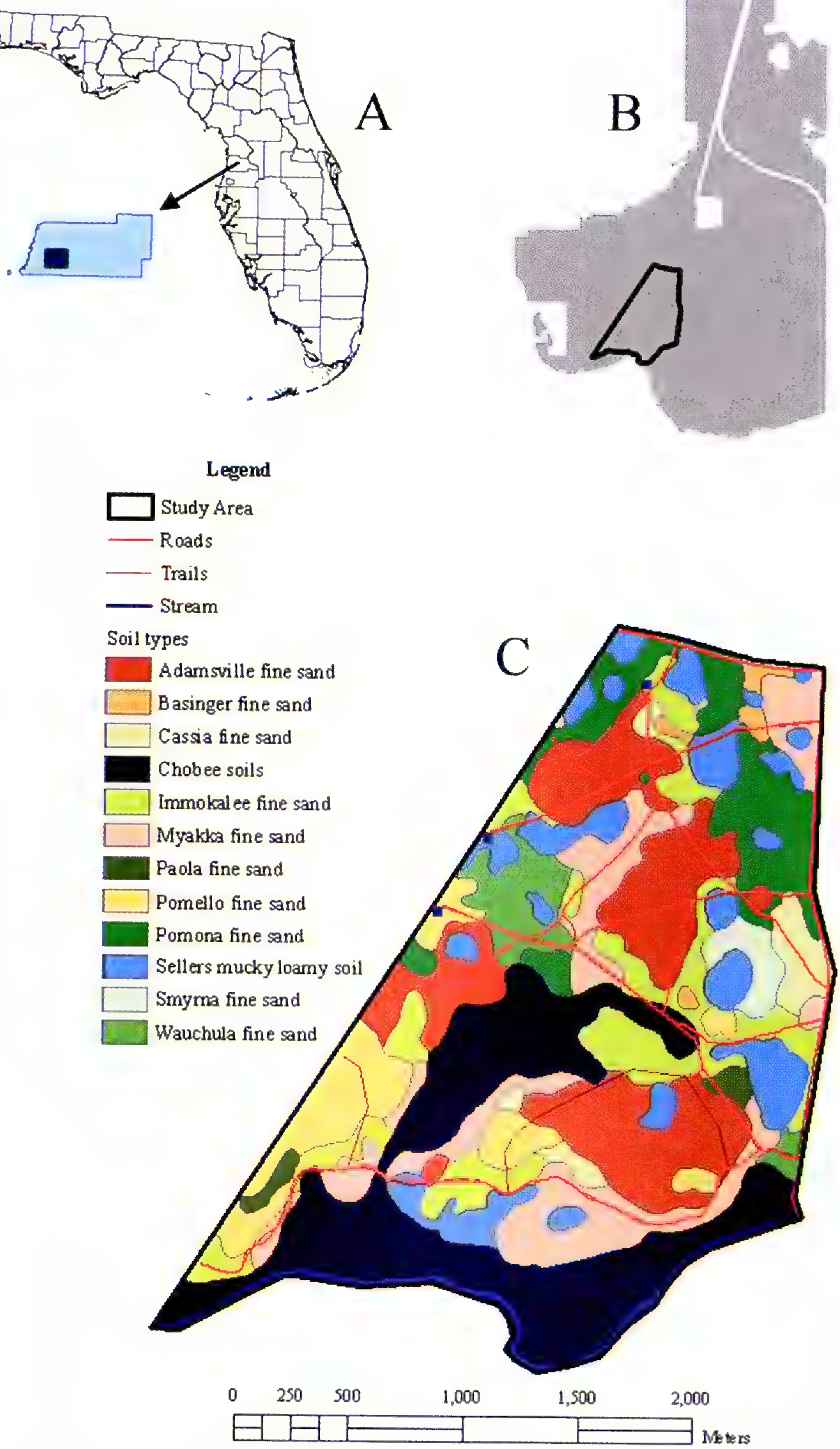


FIG. 1. **A.** Location of the Jay B. Starkey Wilderness Preserve, Pasco County, Florida. **B.** Jay B. Starkey Wilderness Preserve with outline of the study area. **C.** Plant communities in the Jay B. Starkey Wilderness Preserve study area.

and for cypress and pine lumber. In 1937, Jay B. Starkey and his partners, Ernest, Dave, and Howard Cunningham, bought 6,070 hectares. The C-S (Cunningham-Starkey) Ranch was used to raise cattle by both families. As land values increased and cattle yields decreased, portions of the land were sometimes sold to developers. Jay B. Starkey, who outlived his partners, finally sold the cattle and the equipment to his son Jay. B. Starkey, Jr. The senior Starkey still lived and worked the land with his son for cattle ranching, and later during World War II, converted about 30 hectares into an orange grove. Over the years, items such as timber, pine stumps, and resin were sold to provide extra income. In 1975, as the population increased in the county, Jay B. Starkey, Sr. decided to preserve the land from development by selling part of the ranch to SWFWMD with the understanding that SWFWMD would maintain the land in its natural state (Lawson et al. 1981). By 1980, SWFWMD had acquired 1,407.9 hectares (Wells 2004). The SWFWMD has purchased additional property since then and the Starkey Wilderness Preserve now comprises approximately 7,739.5 hectares.

Climate.—The climate of Pasco County is humid and subtropical (Chen & Gerber 1990). The constant cyclical pattern consists of cool, dry winters and warm, humid summers. Annual mean temperature is 22° C (SWFWMD 1988). During the winter months, December through February, the monthly mean temperature is 16° C. The temperature will usually drop to freezing at least once a year. During the summer months, from June to September, the monthly mean temperature is about 27° C, with highs reaching about 33° C.

Rainfall in Pasco County varies seasonally, oscillating between the rainy season and the dry season (SWFWMD 1988). From October to May, rainfall is less than 10.2 cm per month, while during the summer months, June through September, the area receives about 18.4 cm of rainfall per month. This accounts for about half of the rainfall for the year. In spring, central Florida, including Pasco County, experiences harsher and longer, dry drought-like conditions than either northern or southern Florida (Chen & Gerber 1990). The high amounts of rain that fall from June to September are attributed to the convective clouds, sea breezes, and tropical storms. By the beginning of October, the rainfall decreases by about 50 percent from that of the summer months, indicating the beginning of the dry period.

Geology.—The geology underlying the Starkey Wilderness Preserve is the Suwannee Formation deposited during the Oligocene epoch of the Tertiary period (34 to 24 MYBP) (Scott et al. 2001). This formation is a yellow to white, fossiliferous, fine-grained limestone (Wetterhall 1964). It is a very porous formation that contains the Upper Floridan Aquifer. Below the Suwannee Formation are the Ocala and Avon Park Formations, both deposited during the Eocene epoch of the Tertiary period (55 to 34 MYBP). Both of the lower formations are also important parts of the Floridan aquifer.

Soils.—Twelve distinct soil types occur within the study site. The domi-

nant types are: Chobee, frequently flooded (22%); Adamsville fine sand (19%); Myakka fine sand (13%); Immokalee fine sand (11.5%); and Sellers mucky loamy fine sand (10%). Other soil types present are Pomona fine sand (8%); Pomello fine sand, 0 to 5 percent slope (6%); Wauchula fine sand, 0 to 5 percent slope (4%); Cassia fine sand, 0 to 5 percent slope (3%); Smyrna fine sand (1.5%); Paola fine sand (1%); and Basinger fine sand (1%) (Stankey 1982).

Topography and Hydrology.—Starkey Wilderness Preserve is located in the Gulf Coastal Lowlands physiographic province, which is characterized by low elevations and poor drainage. Within the study site, the elevation ranges from 9.1 to 16.8 m (USGS 1974). The majority of the site has an elevation of 10.7 to 12.2 m. The swamp and river floodplain area ranges from 9.1 to 10.7 m.

The Anclote River, located primarily in Pasco County, is 27.4 km long. About 8.1 km of the Anclote, excluding the south branch, is within the Starkey Wilderness Preserve (SWFWMD 1990). The southern border for the study site is an approximately 3.2 km section of the Anclote River (fig. 1). The Anclote is characterized as a slow moving, turbid, acidic, black water stream. The channel is not more than 6 m wide at any point along the southern boundary of the study site. During low flow stage, the stream is confined to the channel. As the rainy season starts, the Anclote overflows its banks inundating the floodplain forest, and remains at flood stage for two to three months. When the river overflows its banks, the water flowing into the floodplain removes waste and provides nutrients to the floodplain community. The sediment load settles out as the water moves out of the channel. Heavier sediments are deposited first closer to the channel due to their weight, and finer, lighter sediments settle out more slowly further away from the channel.

Disturbances Affecting the Study Site.—With the exception of the effects of cattle grazing, lumbering, and other minor events, the study area has undergone few changes. The western boundary of the study site is the right-of-way for the Florida Power Corporation electrical transmission line. This 46 m wide artery was constructed in the 1970s (SWFWMD 1990). In order to maintain the right-of-way the area is frequently mechanically cleared. In addition, SWFWMD built 14 active production water wells within the Preserve. These wells pump water from the Preserve to provide potable water for the city of New Port Richey. Three production wells occur within the study site. An approximately 3,240-hectace portion of the Preserve, the Jay B. Starkey Wilderness Park, is open to the public for a number of recreational opportunities. In order to provide these recreational activities, SWFWMD constructed a paved road, hiking/biking trails, horse riding trails, primitive camp sites, and semi-primitive road beds. A number of these features occur within the study site as well.

The most recent disruption within the study site was a wildfire that was believed to have started from a lightning strike June 3, 2004. After persisting through the night, the wildfire consumed approximately 162 hectares on June

4, primarily in a band through the center of the study site. This fire occurred towards the end of the research collection period and thus had little impact on data collection.

Management Regimes.—The management plan devised and implemented by SWFWMD (1990) includes several conceptual land uses. The most important function for the District is to manage the well field withdrawals. The consumptive use permit renewed in 1979 allows the city of New Port Richey to withdraw 30 to 57 million liters per day from the 14 wells within the Preserve (SWFWMD, 1990). This water withdrawal has produced shorter hydroperiods, lower peak water levels, increased rates of succession into wetland areas, and unusual plant associations (SWFWMD 1990).

To manage areas of historical significance, SWFWMD protects them from disturbance by keeping hiking and horse-riding trails away from them. SWFWMD has opened the Preserve for "low intensity resource-based" recreation by building facilities for local use (SWFWMD 1990). These recreational facilities are managed by Pasco County. They include hiking, biking, horse riding, birding, camping, and any other non-motorized activities. The hiking/biking trails are separate from the horse riding trails to avoid safety hazards.

Land management practices exercised by SWFWMD include a number of ways to improve or preserve the quality of the property. The District uses prescribed burning to conserve various communities and to restore habitats. During the summer months, when there is greater thunderstorm activity, higher lightning frequency giving way to natural wildfires which SWFWMD contains and controls. The District normally burns during the winter months in order to limit and control fires (SWFWMD 1990).

A population of feral hogs has disturbed the soil while rooting, causing damage to some habitats and previously preserved historical sites. Part of the management plan is to reduce or minimize their impact.

METHODS

Vascular plant specimen vouchers were collected from May 2003 to October 2004 using standard field collection and herbarium techniques. Notes were made for each collection regarding the habitat and frequency of occurrence. One complete set of voucher specimens was deposited at the University of South Florida Herbarium (USF). The floras of Wunderlin (1998) and Wunderlin and Hansen (2003) were utilized for identifications, followed by verification with specimens in the USF herbarium.

Vascular plants of special interest include those taxa that are Federal and/or State listed species and exotic species listed by the Florida Exotic Pest Plant Council (FLEPPC 2005). Species unreported for Pasco County as determined by Wunderlin and Hansen (2005) are noted.

The plant community classification for the study site follows that of Florida

Natural Areas Inventory (FNAI 1990). The plant communities are described and include the dominant species found within each layer (overstory, understory, and herbaceous ground layer).

RESULTS AND DISCUSSION

A total of 483 taxa were collected within the study site within Starkey Wilderness Preserve. The flora is comprised of 104 families and 271 genera (Table 1). The families with the greatest number of taxa are: Asteraceae (66), Poaceae (62), Cyperaceae (39), and Fabaceae (28). The genera with the most abundant taxa are: *Rhynchospora* (12), *Quercus* (10), *Hypericum* (9), *Andropogon* (8), *Ludwigia* (8), and *Dichanthelium* (8).

About 92% of the flora in the study site is native. Sixteen (3%) of the species found are endemic to Florida. Four of the 39 non-native taxa are listed by the Florida Exotic Pest Plant Council (FLEPPC 2005). Thirty-three taxa are records for Pasco County (Wunderlin & Hansen 2005). Twelve taxa are listed as endangered, threatened, or commercially exploited in Florida (Coile & Garland 2003). No Federally listed taxa occur on the site.

Starkey Wilderness Preserve consists of 18 plant communities. Eleven of these occur within the study site. Comparing the Preserve with the study site shows the study site is representative of the Preserve (Table 2). The plant communities that fall outside the boundaries of the study site are not dominant ones and contribute only 4% of the total area of the Preserve. Thus the plant list compiled for the study site is fairly representative for the majority of the Preserve.

NATURAL COMMUNITIES

The classification for plant communities found within the study site following the Florida Natural Areas Inventory guidelines (FNAI 1990, 2004) are discussed below from the lowest elevation type to the highest followed by the ruderal areas.

Floodplain Forest.—The floodplain forest is a forested wetland that consists of 64.3 hectares adjacent to the River. Flooding is closely linked to the rain events that occur throughout the summer months. The soil is Chobee (Stankey 1982).

The dominant tree species that make up the overstory of the floodplain forest are *Acer rubrum, Carpinus caroliniana, Fraxinus caroliniana, Ilex cassine, Nyssa sylvatica* var. *biflora, Persea palustris, Quercus laurifolia, Quercus virginiana, Sabal palmetto, Taxodium distichum, Ulmus alata*, and *Ulmus americana*. Some of these are buttressed due to the long hydroperiods. Noteworthy epiphytic species are *Encyclia tampensis, Epidendrum conopseum, Pleopeltis polypodioides*, and *Tillandsia* spp. The woody understory includes *Berchemia scandens, Campsis radicans, Cephalanthus occidentalis, Psychotria nervosa, Psychotria sulzneri*, and *Toxicodendron radicans*. The herbaceous ground layer consists of a number of pteridophytes including *Blechnum*

serrulatum, Osmunda cinnamomea, Osmunda regalis, Thelypteris interrupta,

TABLE 1. Synopsis of the vascular plants found in the Jay B. Starkey Wilderness Preserve study area.

	Taxa	Genera	Families	Endemics	Non-native	Co. Records
Pteridophytes	13	9	7	0	1	2
Gymnosperms	7	4	3	0	0	0
Monocotyledons	164	71	24	2	17	14
Dicotyledons	299	187	70	14	21	17
Totals	483	271	104	16	39	33

TABLE 2. Summary of the plant communities in the Jay B. Starkey Wilderness Preserve and the study area.

Plant Community	SWP	SA	Plant Community	SWP	SA
Basin Marsh	101.2		Oak Scrub	70.4	
Basin Swamp	1,422.1	61.5	Pine Plantation	22.2	
Clastic Upland Lake	10.9		Ruderal and Disturbed	888.3	0.4
Depression Marsh	48.6	2.0	Sand Pine Scrub	206.0	20.2
Dome Swamp	234.7	10.5	Sandhill	275.6	34.4
Dry Prairie	0.8		Scrubby Flatwoods	331.4	40.5
Floodplain Forest	746.2	64.3	Wet Flatwoods	79.3	
Hydric Hammock	28.3		Wet Prairie	40.9	4.1
Mesic Flatwoods	3,005.6	207.2	Xeric Hammock	227.0	4.1

Woodwardia areolata, and *Woodwardia virginica.* Also common are *Carex gigantea, Hypoxis curtissii, Iris hexagona, Rhynchospora miliacea, Saururus cernuus, Scleria triglomerata,* and *Spiranthes odorata.* A non-native species found along the unimproved trails into the floodplain forest is *Urena lobata.*

Basin Swamp.—A basin swamp is a large irregularly-shaped depression that is not part of a river, although during the rainy season it may be connected via surface flow to the river. This region is vegetated by species similar to the floodplain forest. The soils in the study site are Chobee and Sellers mucky loamy fine sand (Stankey 1982); both of these are frequently inundated with water. The study site contains 61.5 hectares of basin swamp. The largest of this community type in the study site is located in the middle of the lower half of the site; it was probably an oxbow originating from the Anclote River.

The dominant overstory species include *Acer rubrum, Carpinus caroliniana, Diospyros virginiana, Fraxinus caroliniana, Gordonia lasianthus, Ilex cassine, Nyssa sylvatica* var. *biflora, Persea palustris, Taxodium distichum, Ulmus alata,* and *Ulmus americana.* The dominant woody understory species are *Cephalanthus occidentalis, Lyonia lucida,* and *Myrica cerifera.* The herbaceous ground layer consists primarily of *Amphicarpum muhlenbergianum,*

Carex spp., *Cladium jamaicense*, *Cyperus* spp., *Eleocharis* spp., *Eriocaulon decangulare*, *Juncus* spp., *Leersia hexandra*, *Panicum hemitomon*, *Peltandra virginica*, *Pontederia cordata*, *Rhexia* spp. *Sagittaria lancifolia*, *Saururus cernuus*, and *Scleria* spp. The basin swamp also contains a number of epiphytic species such as *Pleopeltis polypodioides*, *Tillandsia recurvata*, *Tillandsia simulata*, *Tillandsia usneoides*, and *Tillandsia ×floridana*.

Dome Swamp.—Dome Swamps are found throughout the study site. The study site contains 10.5 hectares of dome swamp. These circular to oblong depressions contain Sellers mucky loamy fine sand, a very poorly-drained soil type (Stankey 1982). An impermeable clay layer beneath the soil helps maintain water levels in these depressions. The depression is due to the soils slumping into sinkholes formed in the limestone rock. Most of the water found in the swamp is surface runoff from surrounding upland communities. The dome swamp may become completely desiccated at the end of the dry season, exposing the peat layer for a couple of weeks. These areas have a domed profile with smaller trees in the shallow water near the edge and larger trees in the deeper water in the middle of the swamp.

The dominant tree in the dome swamp is *Taxodium ascendens*. Other prominent overstory species include *Acer rubrum*, *Diospyros virginiana*, *Ilex cassine*, *Nyssa sylvatica* var. *biflora*, and *Persea palustris*. Typical woody understory species are *Lyonia lucida*, *Myrica cerifera*, *Smilax laurifolia*, and *Toxicodendron radicans*. The herbaceous ground layer includes the pteridophytes *Thelypteris interrupta*, *Woodwardia areolata*, and *Woodwardia virginica*. Other ground layer species are *Drosera capillaris*, *Helenium pinnatifidum*, *Polygala cymosa*, *Polygonum hydropiperoides*, *Rhynchospora latifolia*, *Spiranthes laciniata*, and *Xyris* spp. The epiphytic flora is similar to that of the floodplain forest and basin swamp and includes *Pleopeltis polypodioides*, *Tillandsia recurvata*, *Tillandsia simulata*, *Tillandsia usneoides*, and *Tillandsia ×floridana*. A rare find in one of the swamps was *Vittaria lineata*.

Depression Marsh.—Depression marshes are characterized by low depressions in the flatwoods community due to slumping around the edges of a sinkhole or water collecting on top of a hardpan subsurface layer. Two hectares of depression marsh occur in the study site. The soils are Adamsville fine sand and Basinger fine sand (Stankey 1982).

These regions typically do not contain any overstory species. Woody species include *Hypericum fasciculatum*, *Ilex glabra*, *Myrica cerifera*, and *Stillingia aquatica*. The herbaceous ground layer contains *Amphicarpum muhlenbergianum*, *Carex* spp., *Cyperus* spp., *Eleocharis* spp., *Eriocaulon decangulare*, *Juncus* spp., *Lachnanthes caroliana*, *Panicum hemitomon*, *Rhexia* spp., *Sabatia grandiflora*, *Scleria* spp., and *Xyris* spp.

Wet Prairie.—About 4.1 hectares of the study site is covered by this open wetland herbaceous community. It is often found within the mesic flatwoods

or surrounding the fringe of a dome or basin swamp. The soils are Basinger fine sand and Myakka fine sand (Stankey 1982). The area is poorly drained due to the subsoil layer of hardpan clay.

The wet prairie includes some native invading woody species: *Hypericum fasciculatum*, *Ilex glabra*, *Myrica cerifera*, and *Stillingia aquatica*. The herbaceous ground layer primarily consists of *Aletris lutea*, *Amphicarpum muhlenbergianum*, *Aristida stricta*, *Carex* spp., *Cyperus* spp., *Drosera capillaris*, *Eleocharis* spp., *Eriocaulon decangulare*, *Eupatorium mohrii*, *Fimbrystylis* spp., *Juncus* spp., *Lachnanthes caroliana*, *Panicum hemitomon*, *Polygala* spp., *Rhexia mariana*, *Sabatia* spp., *Scleria* spp., *Syngonanthus flavidulus*, and *Xyris* spp.

Mesic Flatwoods.—The most dominant fire adapted community found in the study site (207.2 hectares) is mesic flatwoods. This community has a relatively flat topography. The dominant soils are Immokalee fine sand, Myakka fine sand, and Smyrna fine sand (Stankey 1982). These soils normally have low levels of nutrients and organic matter. A hardpan clay layer under the soil causes poor water drainage in the rainy season and xeric conditions during the dry season.

The overstory layer is composed of *Pinus elliotti* and *Pinus palustris*. The pines are widely spaced across the community allowing for a dense woody understory layer. The understory layer includes *Ilex glabra*, *Lyonia lucida*, and *Serenoa repens*. Smaller understory layer species are *Gaylussacia frondosa*, *Quercus minima*, *Vaccinium corymbosum*, and *Vaccinium myrsinites*. The rich herbaceous ground layer includes *Amphicarpum muhlenbergianum*, *Aristida stricta*, *Dichanthelium ensifolium*, *Dichanthelium portoricense*, *Elephantopus elatus*, *Eupatorium mohrii*, *Euthamia caroliniana*, *Pityopsis graminifolia*, *Polygala lutea*, *Polygala setacea*, *Pteridium aquilinum*, *Pterocaulon pycnostachyum*, *Seymeria cassioides*, and *Sorghastrum secundum*.

Sandhill.—The sandhill community makes up 34.4 hectares of the study site. There are two areas; both are relatively high in elevation at 12.2–15.2 m and have topography consisting of rolling hills and gentle slopes. The soil of both areas is Adamsville fine sand (Stankey 1982), which is also found under the scrubby flatwoods community within the study site. The deep sandy soils that are easily leached and well drained create xeric characteristics in this community. The overstory layer is sparse, allowing sunlight to reach the ground layer, adding to the xeric condition.

The dominant overstory species include *Pinus palustris*, *Quercus incana*, *Quercus laevis*, and *Quercus margaretta*. Understory species include *Asimina obovata*, *Asimina reticulata*, *Diospyros virginiana*, *Gaylussacia dumosa*, *Licania michauxii*, *Myrica cerifera*, *Quercus minima*, *Rhus copallinum*, and *Serenoa repens*. The herbaceous ground cover layer consists primarily of *Aristida stricta*, *Asclepias humistrata*, *Balduina angustifolia*, *Dichanthelium portoricense*, *Phoebanthus grandiflorus*, *Pityopsis graminifolia*, *Pterocaulon pycnostachyum*, *Rhynchospora megalocarpa*, and *Sorghastrum secundum*.

Scrubby Flatwoods.—This community consists of 40.5 hectares within the study area. The soil is Adamsville fine sand (Stankey 1982). The vegetation consists of a mixture of mesic flatwoods and sand pine scrub species. It is characterized by an open pine canopy with sparse scattered clumps of oak species and patches of open sand.

The species found in the overstory include *Pinus clausa*, *Pinus palustris*, *Quercus chapmanii*, *Quercus geminata*, and *Quercus myrtifolia*. The dense understory layer contains *Garberia heterophylla*, *Lyonia ferruginea*, *Lyonia fruticosa*, *Serenoa repens*, and *Ximenia americana*. The herbaceous ground layer contains *Aristida spiciformis*, *Aristida stricta*, *Carphephorus corymbosus*, *Dichanthelium portoricense*, *Lupinus diffusus*, *Pteridium aquilinum*, and *Rhynchospora megalocarpa*. Several *Pinus palustris* have the epiphyte *Tillandsia ×floridana*.

Sand Pine Scrub.—One area containing a scrub community totaling 20.2 hectares occurs within the study site along the western boundary. This community develops along the ridgeline of ancient dune formations composed of very fine sand sometimes referred to as "sugar sand." The soil is Pomello fine sand (Stankey 1982). These fine sands allow rain water to quickly percolate down to the aquifer creating a xeric growing condition. The scrub can have an open or closed canopy consisting of *Pinus clausa* with various oaks and shrubs dominating the understory. Normally this community type exhibits patches of exposed sand; however, in the study site these are very few. The scrub found within the study site has mature *Pinus clausa*, an indication of fire suppression.

Under the *Pinus clausa*, the dominant overstory also contains *Quercus chapmanii*, *Quercus geminata*, and *Quercus myrtifolia*. The understory shrub layer contains *Asimina obovata*, *Ceratiola ericoides*, *Garberia heterophylla*, *Licania michauxii*, *Lyonia ferruginea*, *Lyonia fruticosa*, *Serenoa repens*, and *Ximenia americana*. The herbaceous ground cover is sparse; however some common herbs found there are *Palafoxia intergrifolia*, *Pityopsis graminifolia*, and *Rhynchospora megalocarpa*.

Xeric Hammock.—Xeric hammock is generally considered a degraded fire-excluded scrub or sandhill community. This community in the study site is an advanced sandhill community and consists of 4.1 hectares on the fringes of the northern sandhill community. The xeric hammock occurs on two soil types, Adamsville fine sand and Immokalee fine sand (Stankey 1982). The community lacks a closed overstory canopy, but a low canopy is present from the shrub layer dominated by oaks.

The overstory species consist of *Pinus palustris* (few), *Quercus geminata*, and *Quercus laevis*. The dense woody understory consists primarily of *Licania michauxii*, *Lyonia fruticosa*, *Quercus chapmanii*, *Quercus myrtifolia*, and *Serenoa repens*. The herbaceous ground layer includes *Aristida stricta*, *Dichanthelium portoricense*, *Galactia elliottii*, *Pteridium aquilinum*, and *Rhynchospora megalocarpa*.

Ruderal.—Ruderal areas within the study site include regions of disturbance due to anthropogenic changes. This encompasses 0.4 hectare of roadsides, hiking trails, horse riding trails, well pump houses, improved pasture, and the fringe of the power line artery. These areas contain a high number of non-native species because of the recent disturbances caused by their construction and subsequent use.

The most prominent non-native is *Paspalum notatum* followed by *Crotalaria* spp., *Indigofera hirsuta*, and *Ludwigia peruviana*. The Southwest Florida Water Management District (SWFWMD) has worked to manage these ruderal areas to encourage recruitment of native species.

ANNOTATED LIST OF THE VASCULAR FLORA

The vascular flora of the study site within the Starkey Wilderness Preserve in the following list is documented by vouchered specimens in the University of South Florida herbarium (USF). The list is divided into four major sections: pteridophytes, gymnosperms, monocots, and dicots (basal angiosperms and eudicots). Within these sections the list is arranged alphabetically by family, genus, and species. The nomenclature follows Wunderlin and Hansen (2003, 2005).

Each species and infraspecific taxon is followed by a common name and its frequency of occurrence. The frequency of occurrence is given as: **R,** rare, less than four individuals found; **O,** occasional, between four and 15 plants noted; and **C,** common, more than 15 plants in the immediate area. Following the frequency of occurrence, the primary plant community from which the species was collected is noted. The plant communities include: basin swamp (**BS**); depression marsh (**DM**); dome swamp (**DW**); floodplain forest (**FF**); mesic flatwoods (**MF**); ruderal (**RD**); sandhill (**SH**); scrubby flatwoods (**SF**); sand pine scrub (**SP**); wet prairie (**WP**); and xeric hammock (**XH**). Following this, taxa listed as endangered, threatened, or commercially exploited in Florida (Coile & Garland 2003) are noted. The number(s) in brackets at the end of each species are the collection number(s) of the first author.

Species endemic to Florida are listed in **bold** font. Non-native species are marked with an asterisk (*). New records for Pasco County are indicated by an underline. Exotic species listed by the Florida Exotic Pest Plant Council (FLEEPC 2005) are listed with their ranking: Category I—species altering Florida's natural plant community by displacing native species and changing the structure of the community; Category II—species having the ability in the future to alter Florida's natural plant communities by displacing natives and changing the community structure.

PTERIDOPHYTES

Blechnaceae

Blechnum serrulatum Rich.—toothed midsorus fern; C; DS (116, 498, 538)

Woodwardia areolata (L.) T. Moore—netted chain fern; C; FF (552, 822)

Woodwardia virginica (L.) Sm.—Virginia chain fern; C; FF (523, 499, 418)

Dennstaedtiaceae

Pteridium aquilinum (L.) Kuhn var. *pseudocaudatum* (Clute) Clute ex A. Heller tailed bracken fern; C; MF (249, 823)

Lycopodiaceae

Lycopodiella alopecuroides (L.) Cranfill—foxtail club-moss; R; BS (266)

Osmundaceae

Osmunda cinnamomea L.—cinnamon fern; C; FF; commercially exploited (347)

Osmunda regalis L. var. *spectabilis* (Willd.) A. Gray—royal fern; O; FF; commercially exploited (553, 655)

Polypodiaceae

Phlebodium aureum (L.) J. Sm.—golden polypody; O; DS (579)

Pleopeltis polypodioides (L.) E.G. Andrews & Windham var. *michauxiana* (Weath.) E.G. Andrews & Windham—resurrection fern; C; FF (398)

Thelypteridaceae

**Thelypteris dentata* (Forssk.) E.P. St. John—downy maiden fern; O; FF (803)

Thelypteris interrupta (Willd.) K. Iwats.—hottentot fern; C; FF (354)

Thelypteris kunthii (Desv.) C.V. Morton—widespread maiden fern; C; FF (554)

Vittariaceae

Vittaria lineata (L.) Sm.—shoestring fern; R; DS (765)

GYMNOSPERMS

Cupressaceae

Juniperus virginiana L.—red cedar; R; RD (782)

Taxodium ascendens Brongn.—pond-cypress; C; DS (170)

Taxodium distichum (L.) Rich.—bald-cypress; C; FF (108)

Pinaceae

Pinus clausa (Chapm. ex Engelm.) Vasey ex Sarg.—sand pine; C; SF (290)

Pinus elliottii Engelm.—slash pine; C; MF (595)

Pinus palustris Mill.—longleaf pine; C; MF (581)

Zamiaceae

Zamia pumila L.—Florida arrowroot; R; MF; commercially exploited (310)

MONOCOTS

Agavaceae

Yucca filamentosa L.—Adam's needle; O; SH (91)

Alismataceae

Sagittaria graminea Michx. var. *graminea*—grassy arrowhead; O; DS (115, 380)

Sagittaria graminea Michx. var. *chapmanii* J.G. Sm.—Chapman's arrowhead; O; FF (480)

Sagittaria lancifolia L.—bulltongue arrowhead; C; DS (528, 716)

Amaryllidaceae

Zephyranthes atamasca (L.) Herb. var. *treatiae* (S. Watson) Meerow—Treat's rainlily; R; FF; threatened (665)

Araceae

Arisaema triphyllum (L.) Schott—Jack-in-the-pulpit; R; FF (740)

Lemna valdiviana Phil.—Valdivia duckweed; C; BS (215)

Peltandra virginica (L.) Schott—green arrow arum; R; BS (776)

Arecaceae

Sabal minor (Jacq.) Pers.—dwarf palmetto; C; FF (316)

Sabal palmetto (Walter) Lodd. ex Schult. & Schult.f.—cabbage palm; O; FF (794)

Serenoa repens (W. Bartram) Small—saw palmetto; C; MF (80)

Bromeliaceae

Tillandsia bartramii Elliott—Bartram's airplant; C; SH (494)

Tillandsia recurvata (L.) L.—ballmoss; C; SH (270)

Tillandsia setacea Sw. southern needleleaf; C; FF (751)

Tillandsia simulata Small—airplant; C; FF (305, 351, 577)

Tillandsia usneoides (L.) L.—Spanish moss; C; SH (452)

Tillandsia utriculata L.—giant airplant; O; SH; endangered (837)
Tillandsia ×floridana (L.B. Sm.) H. Luther; C; SF (306)

Burmanniaceae

Burmannia capitata (J.F.Gmel.) Mart.—southern bluethread; O; DS (509)

Commelinaceae

Callisia ornata (Small) G.C.Tucker—Florida scrub roseling; O; MF (75, 138)
Commelina erecta L.—whitemouth dayflower; O; RD (77, 781)

Cyperaceae

**Bulbostylis barbata* (Rottb.) C.B. Clarke—watergrass; O; RD (838)
Carex gigantea Rudge—giant sedge; C; FF (556, 661)
Carex longi Mack.—Long's sedge; C; FF (546, 558, 602, 830)
Carex verrucosa Muhl.—warty sedge; C; DS (383, 690, 706)
Cladium jamaicense Crantz—Jamaica swamp sawgrass; C; DS (532)
Cyperus croceus Vahl—Baldwin's flatsedge; C; DS (224)
Cyperus haspan L.—haspan flatsedge; C; DM (571, 539)
Cyperus odoratus L.—fragrant flatsedge; C; FF (545, 774)
Cyperus polystachyos Rottb.—manyspike flatsedge; C; DM (160, 243, 295)
Cyperus retrorsus Chapm.—pinebarren flatsedge; C; DM (136, 247, 293, 410)
Cyperus surinamensis Rottb. ssp. *tropica*. flatsedge; C; DM (104, 232, 294, 437)
Eleocharis baldwinii (Torr.) Chapm.—Baldwin's spikerush; C; DS (423, 430, 876)
Eleocharis flavescens (Poir.) Urb. yellow spikerush; C; WP (231, 547)
Eleocharis vivipara Link—viviparous spikerush; C; RD (836)
Fimbristylis autumnalis (L.) Roem. & Schult.—slender fimbry; C; RD (585, 878)
Fimbristylis cymosa R. Br.—hurricanegrass; O; DS (515)
Fimbristylis dichotoma (L.) Vahl—forked fimbry; C; RD (884)
**Fimbristylis schoenoides* (Retz.) Vahl—ditch fimbry; O; RD (851, 879, 880)
Fimbristylis puberula (Michx.) Vahl—hairy fimbry; O; WP (221, 864)
Fuirena breviseta (Coville) Coville—saltmarsh umbrella-sedge; C; DS (169, 513)
Fuirena pumila (Torr.) Spreng.—dwarf umbrella-sedge; C; DS (233)
Fuirena scirpoidea Michx.—southern umbrella-sedge; C; DS (429)
Lipocarpha maculata (Michx.) Torr.—American halfchaff sedge; O; DS (847)
Rhynchospora cephalantha A. Gray—bunched beaksedge; C; FF (521)
Rhynchospora colorata (L.) H. Pfeiff.—starrush whitetop; O; WP (111)
Rhynchospora corniculata (Lam.) A. Gray—shortbristle horned beaksedge; O; RD (833)
Rhynchospora fascicularis (Michx.) Vahl—fascicled beaksedge; C; DM (122, 135, 182, 255, 365, 417, 485)
Rhynchospora fernaldii Gale—Fernald's beaksedge; C; MF (329)
Rhynchospora inundata (Oakes) Fernald—narrowfruit horned beaksedge; C; DS (223, 228, 425, 888)
Rhynchospora latifolia (Baldwin) W.W.Thomas—giant whitetop; O; DS (758)
Rhynchospora megalocarpa A. Gray—sandyfield beaksedge; C; SP (432, 786)
Rhynchospora microcarpa Baldwin ex A. Gray—southern beaksedge; C; DM (831)
Rhynchospora microcephala (Britton) Britton ex Small—bunched beaksedge; C; DS (529, 573)
Rhyncospora miliacea (Lam.) A. Gray—millet beaksedge; C; FF (352, 687)
Rhynchospora plumosa Elliott —plumed beaksedge; C; MF (189, 416, 678, 681)
Scirpus cyperinus (L.) Kunth—woolgrass; O; DM (780)
Scleria baldwinii (Torr.) Steud.—Baldwin's nutrush; C; WP (742)
Scleria reticularis Michx. —netted nutrush; C; WP (428, 859)
Scleria triglomerata Michx.—tall nutgrass; C; SP (187)

Eriocaulaceae

Eriocaulon compressum Lam.—flattened pipewort; C; WP (510)
Eriocaulon decangulare L.—tenangle pipewort; O; DS (225, 505)

Lachnocaulon anceps (Walter) Morong—whitehead bogbutton; C; RD (334, 526)
Syngonanthus flavidulus (Michx.) Ruhland—yellow hatpins; C; MF (85, 674, 703)

Haemodoraceae

Lachnanthes caroliana (Lam.) Dandy—Carolina redroot; O; MF (200)

Hydrocharitaceae

Limnobium spongia (Bosc) Rich. ex Steud.—American sponge plant; O; RD (832)

Hypoxidaceae

Hypoxis curtissii Rose—common yellow stargrass; C; FF (312)
Hypoxis juncea Sm.—fringed yellow stargrass; C; MF (97, 300, 656)

Iridaceae

Iris hexagona Walter—Dixie iris; C; FF (660)
Sisyrinchium nashi E.P. Bicknell—Nash's blue-eyed grass; C; MF (668, 729)
Sisyrinchium rosulatum E.P. Bicknell—annual blue-eyed grass; R; RD (653)

Juncaceae

Juncus dichotomus Elliott—forked rush; O; DM (548, 828)
Juncus effusus L.—soft rush; C; DS (402, 537)
Juncus marginatus Rostk.—shore rush; C; WP (144, 484, 435, 572)
Juncus megacephalus M.A. Curtis—bighead rush; C; DM (242)
Juncus scirpoides Lam.—needlepod rush; C; DS (258, 192, 205, 327, 501)

Liliaceae

Lilium catesbaei Walter—Catesby's lily; O; MF; threatened (371)

Melanthiaceae

Stenanthium densum (Desr.) Zomlefer & Judd—crowpoison; R; MF (805)

Nartheciaceae

Aletris lutea Small—yellow colicroot; O; MF (238, 723)

Orchidaceae

Calopogon tuberosus (L.) Britton et al.—tuberous grasspink; R; MF (793)
Encyclia tampensis (Lindl.) Small—Florida butterfly orchid; O; FF; commercially exploited (662)
Epidendrum conopseum R. Br.—green-fly orchid; O; FF; commercially exploited (350)
Habenaria floribunda Lindl.—toothpetal false reinorchid; C; BS (594)
Pteroglossaspis ecristata (Fernald) Rolfe—giant orchid; O; MF; threatened (817)
Spiranthes laciniata (Small) Ames—lacelip ladiestresses; O; DS; threatened (764)
Spiranthes odorata (Nutt.) Lindl.—fragrant ladiestresses; O; FF (566)
Spiranthes praecox (Walter) S. Watson—greenvein ladiestresses; O; MF (745)
**Zeuxine strateumatica* (L.) Schltr.—soldier's orchid; R; MF (600)

Poaceae

Amphicarpum muhlenbergianum (Schult.) Hitcnc.—blue maidencane; C; BS (427, 514, 549, 877, 883)
Andropogon brachystachyus Chapm.—shortspike bluestem; O; MF (563)
Andropogon glomeratus (Walter) Britton et al. var. *glomeratus*—bushy bluestem; O; DS (436)
Andropogon glomeratus (Walter) Britton et al. var. *glaucopsis* (Elliott) C. Mohr.—purple bluestem; O; MF (251, 536)
Andropogon glomeratus (Walter) Britton et al. var. *pumilus* (Vasey) Vasey ex L.H. Dewey—bushy bluestem; F, WF (476)
Andropogon gyrans Ashe—Elliott's bluestem; C; SH (493, 870)
Andropogon ternarius Michx.—splitbeard bluestem; C; SF (469, 475)
Andropogon virginicus L. var. *decipiens* C.S. Campb.—broomsedge bluestem; C; MF (471, 486)
Andropogon virginicus L. var. *glaucus* Hack.—chalky bluestem; O; SF (493)
Aristida palustris (Chapm.) Vasey—longleaf threeawn; O; MF (845)
Aristida purpurascens Poir. var. *tenuispica* (Hitchc.) Allred—Hillsboro threeawn; C; MF (562, 596, 680)
Aristida purpurascens Poir. var. *virgata* (Trin.) Allred—arrowfeather threeawn; O; WP (488)
Aristida spiciformis Elliott—bottlebrush threeawn; C; MF (308, 364, 415, 474)
Aristida stricta Michx. var. *beyrichiana* (Trin. & Rupr.) D.B. Ward—wiregrass; C; MF (407)
Axonopus furcatus (Flüggé) Hitchc.—big carpetgrass; C; RD (801, 829)
Axonopus fissifolius (Raddi) Kuhlm.—common carpetgrass; O; RD (857)

Cenchrus spinifex Cav.—coastal sandbur; C; MF (307, 319, 409)
Ctenium aromaticum (Walter) A.W. Wood—toothachegrass; O; MF (519, 886)
**Cynodon dactylon* (L.) Pers.—Bermudagrass; O; RD (842)
**Dactyloctenium aegyptium* (L.) Willd. ex Asch. & Schweinf.—Durban crowfootgrass; C; MF (525)
Dichanthelium commutatum (Schult.) Gould—variable witchgrass; C; MF (401, 605, 861)
Dichanthelium dichotomum (L.) Gould—cypress witchgrass; C; MF (557, 684)
Dichanthelium ensifolium (Baldwin ex Elliott) Gould var. *ensifolium* witchgrass; C; WP (190, 411, 540, 675, 712, 865)
Dichanthelium ensifolium (Baldwin ex Elliott) Gould var. *unciphyllum* (Trin.) B.F. Hansen & Wunderlin—cypress witchgrass; O; MF (666)
Dichanthelium erectifolium (Nash) Gould & C.A. Clark—erectleaf witchgrass; C; MF (220)
Dichanthelium laxiflorum (Lam.) Gould—openflower witchgrass; O; MF (800)
Dichanthelium ovale (Elliott) Gould & C.A.Clark—eggleaf witchgrass; F; MF (717)
Dichanthelium portoricense (Desv. ex Ham.) B.F. Hansen & Wunderlin hemlock witchgrass; C; MF (363, 667, 676, 713)
Digitaria ciliaris (Retz.) Koeler —southern crabgrass; O; RD (856, 881)
**Eleusine indica* (L.) Gaertn. -Indian goosegrass; O; RD (841)
**Eragrostis atrovirens* (Desf.) Trin. ex Steud.—Thalia lovegrass; C; WP (229, 257, 543, 575, 583, 844)
Eragrostis elliottii S. Watson—Elliott's lovegrass; C; MF (414, 438, 459)
Eragrostis secundiflora J. Presl subsp. *oxylepis* (Torr.) S.D. Koch—red love-grass; O; MF (811)
Eragrostis virginica (Zuccagni) Steud.—coastal lovegrass; C; WP (412, 569)
**Eremochloa ophiuroides* (Munro) Hack.—centipedegrass; C; RD (872)
Eustachys petraea (Sw.) Desv.—pinewoods fingergrass; C; MF (164, 244)
Leersia hexandra Sw.—southern cutgrass; C; DM (542)
Panicum anceps Michx.—beaked panicum; C; DS (252, 137, 406, 835)
Panicum dichotomiflorum Michx.—fall panicgrass; O; DM (843)
Panicum hemitomon Schult.—maidencane; C; DS (753)
**Panicum repens* L.—torpedograss; C; RD; FLEEPC-I (821)
Panicum rigidulum Bosc ex Nees—redtop panicum; C; BS (439, 490, 848)
Panicum verrucosum Muhl.—warty panicgrass; C; FF (420)
Panicum virgatum L.—switchgrass; C; MF (568)
Paspalum floridanum Michx.—Florida paspalum; O; DS (246)
Paspalum laeve Michaux—field paspalum; O; WP (184)
**Paspalum notatum* Flüggé var. *notatum*—Bahiagrass; O; MF (186)
**Paspalum notatum* Flüggé var. *saurae* Parodi—Bahiagrass; C; MF (756)
Paspalum praecox Walter—early paspalum; C; MF (226)
Paspalum setaceum Michx.—thin paspalum; C; MF (256, 421, 433, 489, 530, 806)
**Paspalum urvillei* Steud.—Vaseygrass; C; WP (245, 757)
**Rhynchelytrum repens* (Willd.) C.E. Hubb.—rose Natalgrass; C; MF; FLEPPC-II (809)
Saccharum giganteum (Walter) Pers.—sugarcane plumegrass; C; DS (424, 550, 582)
**Sacciolepis indica* (L.) Chase Indian cupscale; C; DM (862)
Sacciolepis striata (L.) Nash—American cupscale; C; FF (534)
Schizachyrium scoparium (Michx.) Nash—little bluestem; C; MF (492)
Setaria parviflora (Poir.) Kerguelen—yellow bristlegrass; C; MF (172, 298)
Sorghastrum secundum (Elliott) Nash—lopsided Indiangrass; C; MF (391)
Sphenopholis obtusata (Michx.) Scribn.—prairie wedgescale; C; FF (692)
Sporobolus floridanus Chapm.—Florida dropseed; O; MF (431, 863, 887)
**Sporobolus indicus* (L.) R. Br. smutgrass; C; MF (434)
Sporobolus junceus (P.Beauv.) Kunth—pineywoods dropseed; O; MF (763)

Pontederiaceae

Pontederia cordata L.—pickerelweed; C; BS (109)

Smilacaceae

Smilax auriculata Walter—earleaf greenbrier; C; SH (315)
Smilax bona-nox L.—saw greenbrier; C; FF (555, 672)
Smilax glauca Walter—cat greenbrier; O; FF (818)
Smilax laurifolia L.—laurel greenbrier; C; BS (522, 561, 592)
Smilax pumila Walter—sarsaparilla vine; O; SF (689)

Typhaceae

Typha latifolia L.—broadleaf cattail; O; WP (773)

Xyridaceae

Xyris ambigua Beyr. ex Kunth—coastalplain yelloweyed grass; C; MF (165)
Xyris caroliniana Walter—Carolina yelloweyed grass; C; MF (139, 814)
Xyris elliottii Chapm.—Elliott's yelloweyed grass; C; WP (133)
Xyris fimbriata Elliott—fringed yelloweyed grass; C; DS (389)
Xyris flabelliformis Chapm.—Savannah yelloweyed grass; O; RD (644)
**Xyris jupicai* Rich.—Richard's yelloweyed grass; C; RD (145, 166, 544)
Xyris platylepis Chapm.—tall yelloweyed grass; C; WP (214)

DICOTS

Acanthaceae

Dyschoriste oblongifolia (Michx.) Kuntze—oblongleaf twinflower; O; SH (750)
Ruellia ciliosa Pursh—ciliate wild petunia; O; SH (322)

Adoxaceae

Sambucus nigra L. subsp. *canadensis* (L.) Bolli—American elder; O; BS (769)
Viburnum obovatum Walter—Walter's viburnum; C; FF (346, 686)

Amaranthaceae

**Chenopodium ambrosioides* L.—Mexican tea; C; RD (789)
Froelichia floridana (Nutt.) Moq.—cottonweed; C; SH (194)

Anacardiaceae

Rhus copallinum L.—winged sumac; O; SH (361)
Toxicodendron radicans (L.) Kuntze—eastern poison ivy; C; DS (533)

Annonaceae

Asimina angustifolia Raf.—slimleaf pawpaw; O; SH (718)
Asimina obovata (Willd.) Nash—big flower pawpaw; C; SP (650, 704, 785)
Asimina reticulata Shuttlew. ex Chapm.—netted pawpaw; C; SH (449, 636)

Apiaceae

Eryngium baldwinii Spreng.—Baldwin's eryngo; O; FF (87, 737)
Eryngium yuccifolium Michx.—button rattlesnakemaster; O; SH (143)
Oxypolis filiformis (Walter) Britton—water cowbane; C; RD (426, 578)
Ptilimnium capillaceum (Michx.) Raf.—mock bishopsweed; C; DM (105, 759, 790)

Apocynaceae

Asclepias feayi Chapm. ex A. Gray—Florida milkweed; C; MF (78, 96)
Asclepias humistrata Walter—pinewoods milkweed; C; SH (696)
Asclepias longifolia Michx.—longleaf milkweed; O; WP (227)
Asclepias pedicellata Walter—Savannah milkweed; O; MF (212)
Asclepias tomentosa Elliott—velvetleaf milkweed; O; SH (810)
Asclepias tuberosa L.—butterflyweed; O; SH (88)

Aquifoliaceae

Ilex cassine L.—dahoon; C; FF (397)
Ilex glabra (L.) A. Gray—gallberry; C; DM (259, 362, 450)

Araliaceae

Centella asiatica (L.) Urb.—spadeleaf; C; DS (819)
Hydrocotyle umbellata L.—manyflower marshpennywort; C; DS (654, 721)
Hydrocotyle verticillata Thunb.—whorled marshpennywort; O; FF (804)

Asteraceae

Acmella oppositifolia (Lam.) R.K. Jansen var. *repens* (Walter) R.K. Jansen—oppositeleaf spotflower; O; DM (468)
Ambrosia artemisiifolia L.—common ragweed; C; MF (296, 318)
Baccharis halimifolia L.—groundsel tree; C; SH (455, 477)
Balduina angustifolia (Pursh) B.L. Rob.—

coastalplain honeycombhead; C; SH (208, 267, 271)

Bidens alba (L.) DC. var. *radiata* (Sch. Bip) R.E. Ballard ex Melchert—beggarticks; C; RD (285)

Bigelowia nudata (Michx.) DC. subsp. *australis* L.C. Anderson—pineland rayless goldenrod; C; MF (374, 727)

Boltonia diffusa Elliott—smallhead doll's daisy; C; RD (481)

Carphephorus corymbosus (Nutt.) Torr. & A. Gray—coastalplain chaffhead; O; SF (291)

Carphephorus odoratissimus (J.F.Gmel.) H. Hebert var. *subtropicanus* (DeLaney et al.) Wunderlin & B.F. Hansen—vanillaleaf; C; MF (303)

Carphephorus paniculatus (J.F. Gmel.) H. Hebert—hairy chaffhead; C; WP (495)

Chaptalia tomentosa Vent.—woolly sunbonnets; C; DM (580, 611)

Chrysopsis mariana (L.) Elliott—Maryland goldenaster; C; MF (791)

Chrysopsis subulata Small—scrubland goldenaster; C; MF (161, 197, 207, 815)

Cirsium horridulum Michx.—purple thistle; O; MF (691)

Cirsium nuttallii DC.—Nuttall's thistle; O; MF (195, 203)

Conyza canadensis (L.) Cronquist var. *pusilla* (Nutt.) Cronquist—dwarf Canadian horseweed; C; RD (171, 317, 358)

Coreopsis floridana E.B. Smith—Florida tickseed; O; DS (576)

Coreopsis leavenworthii Torr. & A. Gray—Leavenworth's tickseed; O; MF (158)

Croptilon divaricatum (Nutt.) Raf.—slender scratchdaisy; C; RD (551, 890)

Elephantopus elatus Bertol.—tall elephantsfoot; C; SH (152, 283, 325)

Erechtites hieraciifolius (L.) Raf. ex DC.—fireweed; C; DS (146, 254)

Erigeron quercifolius Poir.—oakleaf fleabane; C; MF (100, 657)

Erigeron vernus (L.) Torr. & A. Gray—early whitetop fleabane; C; MF (162, 372, 574, 747)

Eupatorium capillifolium (Lam.) Small ex Porter & Britton—dogfennel; C; MF (483)

Eupatorium compositifolium Walter—yankeeweed; C; DS (441, 458, 478)

Eupatorium mohrii Greene—Mohr's throughwort; C; MF (121, 448, 777)

Eupatorium rotundifolium L.—roundleaf throughwort; C; MF (209, 235)

Eupatorium serotinum Michx.—lateflowering throughwort; C; DM (344)

Euthamia caroliniana (L.) Greene ex Porter & Britton—slender flattop goldenrod; C; MF (442)

Gaillardia pulchella Foug.—firewheel; O; RD (90, 181)

Gamochaeta antillana (Urb.) Anderb.—Caribbean purple everlasting; O; RD (640)

Gamochaeta pensylvanica (Willd.) Cabrera—Pennsylvania everlasting; O; RD (641)

Garberia heterophylla (W. Bartram) Merr. & F. Harper—garberia; O; SP; threatened (512)

Helenium pinnatifidum (Schwein. ex Nutt.) Rydb.—southeastern sneezeweed; O; DS (725)

Helianthus angustifolius L.—narrowleaf sunflower; C; DS (464)

Helianthus radula (Pursh) Torr. & A. Gray—stiff sunflower; O; MF (356)

Heterotheca subaxillaris (Lam.) Britton & Rusby—camphorweed; C; SH (366, 444, 535)

Hieracium gronovii L.—queendevil; O; SH (454, 603)

Hieracium megacephalon Nash—coastalplain hawkweed; C; MF (174, 193, 260, 264)

Iva microcephala Nutt.—piedmont marshelder; C; DS (466, 531)

Krigia virginica (L.) Willd.—Virginia dwarfdandelion; C; RD (637)

Lactuca graminifolia Michx.—grassleaf lettuce; C; RD (720, 760)

Liatris gracilis Pursh—slender gayfeather; C; SH (250, 375, 392)

Liatris pauciflora Pursh—fewflower gayfeather; O; SH (324)

Liatris spicata (L.) Willd.—dense gayfeather; O; SH (378)

Liatris tenuifolia Nutt.—shortleaf gayfeather; C; SH (403)

Lygodesmia aphylla (Nutt.) DC.—rose-rush; C; MF (81, 302)

Mikania scandens (L.) Willd. climbing hempvine; O; FF (110, 382, 869)

Oclemena reticulata (Pursh) G.L. Nesom—whitetopped aster; C; DS (156, 447, 496, 711)

Palafoxia intergrifolia (Nutt.) Torr & A. Gray—coastalplain palafox; O; SH (154)

Phoebanthus grandiflorus (Torr. & A. Gray) S.F. Blake—Florida false sunflower; C; MF (129, 311, 587)
Pityopsis graminifolia (Nutt.) Michx.—narrowleaf silkgrass; C; MF (261, 599)
Pluchea foetida (L). DC.—stinking camphorweed; O; DS (343)
Pluchea rosea R.K. Godfrey—rosy camphorweed; C; FF (101, 149, 198, 820)
Pseudognaphalium obtusifolium (L.) Hilliard & B.L. Burtt—sweet everlasting; C; MF (393)
Pterocaulon pycnostachyum (Michx.) Elliott—blackroot; C; MF (79)
Pyrrhopappus carolinianus (Walter) DC.—Carolina desertchicory; O; XH (394)
Sericocarpus tortifolius (Michx.) Nees—whitetop aster; C; MF (178, 445, 516)
Solidago fistulosa Mill.—pinebarren goldenrod; C; MF (443, 456)
Solidago odora Aiton var. *chapmanii* (Torr. & A. Gray) Cronquist—Chapman's goldenrod; C; SH (153,282)
Solidago stricta Aiton—wand goldenrod; C; MF (503)
Symphyotrichum adnatum (Nutt.) G.L. Nesom—scaleleaf aster; O; MF (597)
Symphyotrichum carolinianum (Walter) Wunderlin & B.F. Hansen – climbing aster; O; FF (586)
Symphyotrichum dumosum (L.) G.L. Nesom—rice button aster; C; SH (491, 504, 731)
Symphyotrichum subulatum (Michx.) G.L. Nesom—annual saltmarsh aster; C; DM (874)
Vernonia gigantea (Walter) Trel. ex Branner & Coville—giant ironweed; O; FF (860)

Betulaceae

Carpinus caroliniana Walter—American hornbeam; O; FF (341)

Bignoniaceae

Campsis radicans (L.) Seem. ex Bureau—trumpet creeper; O; FF (313)

Brassicaceae

Lepidium virginicum L.—Virginia pepperweed; C; RD (652)

Cactaceae

Opuntia humifusa (Raf.) Raf.—pricklypear; C; SH (217)

Campanulaceae

Lobelia cardinalis L.—cardinalflower; O; FF, threatened (396)
Lobelia glandulosa Walter—glade lobelia; O; MF (507)
Lobelia paludosa Nutt.—white lobelia; C; MF (275, 722, 821)
Triodanis perfoliata (L.) Nieuwl.—clasping Venus's lookingglass; O; RD (714)
**Wahlenbergia marginata* (Thunb.) A. DC.—southern rockbell; C; RD (216, 715)

Caryophyllaceae

Drymaria cordata (L.) Willd. Ex Schult. –West Indian chickweed; O; RD (607)
Stipulicida setacea Michx. var. *lacerata* C.W. James—pineland scalypink; C; SP (659)

Chrysobalanaceae

Licania michauxii Prance—gopher apple; C; SH (95)

Cistaceae

Helianthemum carolinianum (Walter) Michx.—Carolina frostweed; C; MF (634, 761)
Helianthemum corymbosum Michx.—pinebarren frostweed; C; SH (180, 616, 639)
Lechea torreyi (Chapm.) Legg. ex Britton—piedmont pinweed; C; MF (210, 629, 853)

Clusiaceae

Hypericum cistifolium Lam.—roundtop St. John's-wort; C; WP (117, 213, 335, 157, 646)
Hypericum fasciculatum Lam. –peelbark St. John's-wort; C; DS (234, 520)
Hypericum gentianoides (L.) Britton et al.—pineweeds; C; DS (196, 239, 279, 570)
Hypericum hypericoides (L.) Crantz—St. Andrew's-cross; C; DS (142, 348, 446, 834)
Hypericum mutilum L.—dwarf St. John's-wort; C; DS (99, 112)
Hypericum myrtifolium Lam.—myrtleleaf St. John's-wort; C; WP (86, 177)
Hypericum reductum (Svenson) W.P. Adams—Atlantic St. John's-wort; O; SH (796)
Hypericum setosum L.—hairy St. John's-wort; O; DS (373)
Hypericum tetrapetalum Lam.—fourpetal St. John's-wort; C; MF (176, 206)

Convolvulaceae

Ipomoea sagittata Poir.—saltmarsh morningglory; O; DS (812)

Stylisma patens (Desr.) Myint—coastalplain dawnflower; O; SH (269, 272)

Cornaceae

Cornus foemina Mill.—swamp dogwood; O; FF (685)

Nyssa sylvatica Marshall var. *biflora* (Walter) Sarg.—swamp tupelo; C; FF (705, 728, 779)

Droseraceae

Drosera capillaris Poir.—pink sundew; C; DS (120, 726)

Ebenaceae

Diospyros virginiana L.—common persimmon; C; SF (702)

Ericaceae

Bejaria racemosa Vent.—tarflower; C; SF (118, 292, 487)

Ceratiola ericoides Michx.—Florida rosemary; O; SP (787)

Gaylussacia dumosa (J. Kenn.) Torr. & A. Gray—dwarf huckleberry; C; SH (669, 738, 795)

Gaylussacia frondosa (L.) Torr. & A. Gray ex Torr. var. *tomentosa* A. Gray—blue huckleberry; O; MF (649)

Lyonia ferruginea (Walter) Nutt.—rusty staggerbush; O; SF (732)

Lyonia fruticosa (Michx.) G.S. Torr.—coastalplain staggerbush; O; SF (612, 733)

Lyonia lucida Lam.—fetterbush; C; DS (287, 560, 591, 613)

Vaccinium corymbosum L.—highbush blueberry; O; MF (627)

Vaccinium myrsinites Lam.—shiny blueberry; C; MF (76, 615, 642)

Vaccinium stamineum L.—deerberry; O; SH (651, 673)

Euphorbiaceae

Acalypha gracilens A. Gray—slender threeseed mercury; O; RD (802)

Chamaesyce hirta (L.) Millsp.—pillpod sandmat; O; RD (839)

Chamaesyce hyssopifolia (L.) Small—hyssopleaf sandmat; C; RD (387)

Chamaesyce maculata (L.) Small—spotted sandmat; O; RD (866)

Cnidoscolus stimulosus (Michx.) Engelm. & A. Gray—tread-softly; O; SH (253)

Croton glandulosus L.—vente conmigo; O; RD (840)

Croton michauxii G.L. Webster—rushfoil; C; SH (131, 788, 816)

**Phyllanthus urinaria* L.—chamber bitter; O; RD (855)

Stillingia aquatica Chapm.—water toothleaf; O; BS (222)

Stillingia sylvatica L.—queen's delight; O; SH (102, 168)

Fabaceae

Amorpha herbacea Walter—clusterspike false indigobush; O; SH (94)

Apios americana Medik.—groundnut; O; DS (813)

Centrosema virginianum (L.) Benth.—spurred butterfly pea; C; SH (92, 284, 323)

Chamaecrista fasciculata (Michx.) Greene—partridge pea; C; SH (163, 278)

Chamaecrista nictitans (L.) Moench var. *aspera* (Muhl. ex Elliott) H.S. Irwin & Barneby—sensitive pea; C; SH (321)

**Crotalaria lanceolata* E. Mey—lanceleaf rattlebox; O; RD (236, 850)

**Crotalaria pallida* Aiton var. *obovata* (G. Don) Polhill—smooth rattlebox; O; RD (218)

Crotalaria rotundifolia J.F. Gmel.—rabbitbells; C; SH (126, 127, 326, 405, 670)

**Crotalaria spectabilis* Roth—showy rattlebox; C; RD (479)

**Desmodium incanum* DC.—tickfoil; C; RD (248, 386)

Desmodium paniculatum (L.) DC.—panicled ticktrefoil; O; SH (408, 470)

**Desmodium triflorum* (L.) DC.—threeflower ticktrefoil; O; RD (807)

Galactia elliottii Nutt.—Elliott's milkpea; O; SH (159, 749)

Galactia regularis (L.) Britton et al.—eastern milkpea; O; MF (824)

Galactia volubilis (L.) Britton—downy milkpea; C; SH (357, 767, 784, 854)

Indigofera caroliniana Mill.—Carolina indigo; C; SH (873, 875)

**Indigofera hirsuta* L.—hairy indigo; C; RD (457)

**Indigofera spicata* Forssk.—trailing indigo; O; RD (826)

Lespedeza hirta (L.) Hornem.—hairy lespedeza; C; SF (891)

Lupinus diffusus Nutt.—skyblue lupine; O; SH (635)

**Macroptilium lathyroides* (L.) Urb.—wild bushbean; O; RD (124)

**Medicago lupulina* L.—black medick; O; RD (710)
Mimosa quadrivalvis L. var. *angustata* (Torr. & A. Gray) Barneby—sensitive brier; O; SH (268)
Rhynchosia michauxii Vail—Michaux's snout-bean; O; SH (671)
Senna obtusifolia (L.) H.S. Irwin & Barneby—coffeeweed; O; RD (868)
Tephrosia chrysophylla Pursh—scurf hoarypea; O; RD (867)
Tephrosia hispidula (Michx.) Pers.—sprawling hoarypea; O; SH (885)
Vicia acutifolia Elliott—fourleaf vetch; O; FF (708)

Fagaceae

Quercus chapmanii Sarg.—Chapman's oak; O; SF (695, 701)
Quercus geminata Small—sand live oak; C; SH (453)
Quercus incana W. Bartram—bluejack oak; O; SH (694)
Quercus laevis Walter—turkey oak; C; SH (472, 473)
Quercus laurifolia Michx.—laurel oak; O; FF (314, 463)
Quercus margaretta Ashe ex Small—sand post oak; R; SH (762)
Quercus minima (Sarg.) Small—dwarf live oak; C; SH (179, 320, 419)
Quercus myrtifolia Willd.—myrtle oak; C; SF (333, 462)
Quercus nigra L.—water oak; O; MF (309)
Quercus virginiana Mill.—live oak; O; DS (746)

Gelsemiaceae

Gelsemium sempervirens (L.) Aiton f.—yellow jessamine; O; SF (620)

Gentianaceae

Sabatia brevifolia Raf.—shortleaf rosegentian; O; MF (286, 301)
Sabatia calycina (Lam.) A. Heller—coastal rosegentian; O; FF (739)
Sabatia grandiflora (A. Gray) Small—largeflower rosegentian; C; DM (262, 390, 518)

Geraniaceae

Geranium carolinianum L.—Carolina cranesbill; O; RD (709)

Haloragaceae

Proserpinaca pectinata Lam.—combleaf mermaidweed; O; DM (564, 741, 768)

Iteaceae

Itea virginica L.—Virginia willow; O; BS (664)

Lamiaceae

Callicarpa americana L.—American beautyberry; O; MF (119)
Hyptis alata (Raf.) Shinners—musky mint; C; DM (274, 331, 345)
**Hyptis mutabilis* (Rich.) Briq.—tropical bushmint; O; FF (173, 276)
Lycopus rubellus Moench—taperleaf waterhorehound; F; DM (511)
Piloblephis rigida (W. Bartram ex Benth.) Raf.—wild pennyroyal; O; MF (630)
Salvia lyrata L.—lyreleaf sage; O; BS (606)
Scutellaria arenicola Small—Florida scrub skullcap; C; SH (132)
Teucrium canadense L.—woodsage; C; DM (113)
Trichostema dichotomum L.—forked bluecurls; C; MF (377)

Lauraceae

**Cinnamomum camphora* (L.) J. Presl—camphortree; R; BS; FLEPPC-I (734)
Persea palustris (Raf.) Sarg.—swamp bay; C; FF (289, 353)

Lentibulariaceae

Pinguicula pumila Michx.—small butterwort; O; MF (588)
Utricularia foliosa L.—leafy bladderwort; O; DS (527, 771)
Utricularia inflata Walter—floating bladderwort; O; BS (626)
Utricularia juncea Vahl—southern bladderwort; O; DM (369)
Utricularia subulata L.—zigzag bladderwort; O; WP (273)

Linaceae

Linum medium (Planch.) Britton var. *texanum* (Planch.) Fernald—stiff yellow flax; O; WP (797)

Loganiaceae

Mitreola petiolata (J.F. Gmel.) Torr. & A. Gray—lax hornpod; O; DS (497)
Mitreola sessilifolia (J.F. Gmel.) G. Don—swamp hornpod; C; WP (148, 370, 379, 852)

Lythraceae

**Cuphea carthagenensis* (Jacq.) J.F. Macbr.—Colombian waxweed; C; FF (219, 508, 799)

Lythrum alatum Pursh var. *lanceolatum* (Elliott) Torr.& A. Gray ex Rothr.—winged loosestrife; O; MF (277)

Magnoliaceae

Magnolia virginiana L.—sweetbay; R; DS (658)

Malvaceae

**Urena lobata* L.—caesarweed; C; FF; FLEPPC-II (500)

Melastomataceae

Rhexia cubensis Griseb.—West Indian meadowbeauty; O; DS (183)

Rhexia mariana L.—pale meadowbeauty; C; DS (84, 697, 744)

Rhexia nuttallii C.W. James—Nuttall's meadowbeauty; O; MF (185, 506)

Myricaceae

Myrica cerifera L.—wax myrtle; C; MF (332, 693)

Nymphaeaceae

Nymphaea odorata Aiton—American white waterlily; O; BS (752)

Nuphar advena (Aiton) Aiton f.—spatterdock; O; BS (754)

Olacaceae

Ximenia americana L.—tallow wood; O; SP (460)

Oleaceae

Fraxinus caroliniana Mill.—Carolina ash; C; FF (107, 337, 778)

Onagraceae

Gaura angustifolia Michx.—southern beeblossom; O; MF (125, 128)

Ludwigia linearis Walter—narrowleaf primrosewillow; C; DS (280, 385, 451)

Ludwigia linifolia Poir.—southeastern primrosewillow; C; DM (265, 699)

Ludwigia maritima R.M. Harper—seaside primrosewillow; O; MF (147, 201, 263)

Ludwigia microcarpa Michx.—smallfruit primrosewillow; O; DS (297)

Ludwigia octovalvis (Jacq.) Raven—Mexican primrosewillow; O; DM (384, 541)

**Ludwigia peruviana* (L.) H. Hara—Peruvian primrosewillow; O; RD (825)

Ludwigia repens J.R. Forst.—creeping primrosewillow; C; FF (772)

Ludwigia suffruticosa Walter—shrubby primrosewillow; O; DS (240)

Oenothera laciniata Hill—cutleaf eveningprimrose; O; RD (204, 638)

Orobanchaceae

Agalinis fasciculata (Elliott) Raf.—beach false foxglove; C; MF (359, 381)

Agalinis linifolia (Nutt.) Britton—flaxleaf false floxglove; O; DM (846)

Agalinis tenuifolia (Vahl) Raf.—slenderleaf false foxglove; O; MF (502)

Buchnera americana L.—American bluehearts; O; MF (123, 755)

Seymeria cassioides (J.F. Gmel.) S.F. Blake—yaupon blacksenna; O; MF (237, 376, 422)

Seymeria pectinata Pursh—piedmont blacksenna; O; SH (368)

Oxalidaceae

Oxalis corniculata L.—common yellow woodsorrel; O; RD (617)

Passifloraceae

Passiflora incarnata L.—purple passionflower; O; RD (155)

Plantaginaceae

Plantago virginica L.—Virginia plantain; O; RD (648)

Polygalaceae

Polygala cymosa Walter—tall pinebarren milkwort; O; DS (724)

Polygala lutea L.—orange milkwort; C; MF (83, 188)

Polygala nana (Michx.) DC.—candyroot; C; MF (82, 281)

Polygala rugelii Shuttlew. ex Chapm.—yellow milkwort; O; WP (175)

Polygala setacea Michx.—coastalplain milkwort; C; MF (98, 211, 748)

Polygala violacea Aubl.—showy milkwort; C; MF (93)

Polygonaceae

Polygonella gracilis Meisn.—tall jointweed; O; SH (367, 404, 567)

Polygonella polygama (Vent.) Engelm. & A. Gray—October flower; C; SH (395, 461)

Polygonum hydropiperoides Michx.—swamp smartweed; C; DS (114, 399, 482)

Polygonum punctatum Elliott—dotted smartweed; C; RD (400)

Rumex hastatulus Baldwin—heartwing dock; O; RD (719)

Portulacaceae

**Portulaca amilis* Speg.—Paraguayan purslane; O; RD (808)

Primulaceae

Samolus valerandi L. subsp. *parviflorus* (Raf.) Hulten—pineland pimpernel; O; FF (349)

Rhamnaceae

Berchemia scandens (Hill) K. Koch.—rattan vine; O; FF (336)

Rosaceae

Photinia pyrifolia (Lam.) K.R. Robertson & J.B. Phipps—red chokecherry; O; DS (628)

Prunus caroliniana (Mill.) Aiton—Carolina laurelcherry; O; RD (631)

Prunus serotina Ehrh.—black cherry; O; RD (632)

Rubus argutus Link—sawtooth blackberry; C; DS (645, 663)

Rubus cuneifolius Pursh—sand blackberry; C; MF (730)

Rubus trivialis Michx.—southern dewberry; O; FF (792)

Rubiaceae

Cephalanthus occidentalis L.—common buttonbush; C; DS (524, 770)

Diodia teres Walter—rough buttonweed; C; SH (304)

Diodia virginiana L.—Virginia buttonweed; C; BS (106, 199, 388)

Galium tinctorium L.—stiff marsh bedstraw; C; RD (598)

Houstonia procumbens (J.F. Gmel.) Standl.—innocence; C; MF (589, 604)

Mitchella repens L.—partridgeberry; O; FF (340, 688)

Oldenlandia uniflora L.—clustered mille graine; C; DS (413, 882, 889)

Psychotria nervosa Sw.—wild coffee; C; FF (339)

Psychotria sulzneri Small—shortleaf wild coffee; C; FF (338)

**Richardia brasiliensis* Gomes—tropical Mexican clover; C; RD (202)

Spermacoce assurgens Ruiz & Pav.—woodland false buttonweed; O; DM (241)

Spermacoce prostrata Aubl.—prostrate false buttonweed; O; FF (299)

Salicaceae

Salix caroliniana Michx.—Carolina willow; C; RD (633)

Sapindaceae

Acer rubrum L.—red maple; C; FF (590)

Saururaceae

Saururus cernuus L.—lizard's tail; C; FF (585)

Solanaceae

Solanum americanum Mill.—American black nightshade; O; FF (593)

Tetrachondraceae

Polypremum procumbens L.—rustweed; C; RD (130)

Theaceae

Gordonia lasianthus (L.) J. Ellis—loblolly bay; O; BS (288, 559)

Ulmaceae

Ulmus alata Michx.—winged elm; O; FF (682)

Ulmus americana L.—American elm; O; FF (619, 735)

Urticaceae

Boehmeria cylindrica (L.) Sw.—false nettle; C; DS (342, 584)

Verbenaceae

Phyla nodiflora (L.) Greene—turkey tangle fogfruit; C; RD (89)

**Verbena brasiliensis* Vell.—Brazilian vervain; O; RD (775)

Verbena scabra Vahl—sandpaper vervain; O; MF (849)

Veronicaceae

Bacopa monnieri (L.) Pennell herb-of-grace; O; DM (625)

Gratiola hispida (Benth. ex Lindl.) Pollard—rough hedgehyssop; O; MF (140, 141)

Gratiola pilosa Michx.—shaggy hedgehyssop; O; BS (103, 167, 766)

Gratiola ramosa Walter—branched hedgehyssop; O; DS (698)

Linaria canadensis (L.) Chaz.—Canadian toadflax; C; DS (622, 643)

**Lindernia crustacea* (L.) F. Muell.—Malaysian false pimpernel; O; RD (440)

Mecardonia acuminata (Walter) Small subsp. *peninsularis* (Pennell) Rossow—axilflower; C; WP (230, 743)

Micranthemum glomeratum (Chapm.) Shinners—manatee mudflower; O; WP (623)

Scoparia dulcis L.—sweetbroom; C; MF (151)

Violaceae

Viola lanceolata L.—bog white violet; O; DS (624)
Viola palmata L.—early blue violet; O; MF (647)
Viola primulifolia L.—primroseleaf violet; C; DS (601, 618)
Viola sororia Willd.—common blue violet; O; FF (621)

Viscaceae

Phoradendron leucarpum (Raf.) Reveal & M.C. Johnst.—oak mistletoe; O; BS (465)

Vitaceae

Ampelopsis arborea (L.) Koehne—peppervine; O; DS (150)
Parthenocissus quinquefolia (L.) Planch.—Virginia creeper; O; MF (783)
Vitis rotundifolia Michx.—muscadine; C; MF (360)
Vitis shuttleworthi House—calloose grape; O; MF (736)

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Book Notice

Julian A. Steyermark, Paul E. Berry, Kay Yatskievych, and Bruce K. Holst (Eds.). **Flora of the Venezuelan Guayana. Vol. 9, Rutaceae–Zygophyllaceae**. (ISBN 1-930723-47-4, hbk.). Missouri Botanical Garden Press, P.O. Box 299, Saint Louis, MO 63166-0299, U.S.A. (**Orders:** http://www.mbgpress.info/). 608 pp., 502 b/w line drawings, 7 1/4" × 10 1/2".

The final volume of the series, concluding the taxonomic treatment of all native and naturalized vascular plant families known to occur in the Venezuelan Guayana. Forty-six contributors in Volume 9 treat 48 families—190 genera and 971 species illustrated by 503 figures. Ceratophyllaceae is included (recognized for the flora area after its volume was published) as are segregates Bonnetiaceae (from Theaceae), Muntingiaceae (from Tiliaceae), and Picramniaceae (from Simaroubaceae).—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A*

Editor's note.—Two new names are published: *Sterculia kayae* P.E. Berry, nom. nov. and *Xyris sulcatifolia* Kral, nom. nov.

VASCULAR FLORAS OF SONOITA CREEK STATE NATURAL AREA AND SAN RAFAEL STATE PARK: ARIZONA'S FIRST NATURAL-AREA PARKS

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ABSTRACT

Sonoita Creek State Natural Area (SCSNA) and San Rafael State Park (SRSP) are the first two natural-area parks in Arizona established with funding provided by the Heritage Initiative. Both sites are in Santa Cruz County, and both have riparian communities that are rare in the arid Southwest. The upland vegetation of SCSNA is primarily semidesert grassland, while that of SRSP is Plains grassland. The flora of SCSNA includes 525 native species and 36 exotic species; that of SRSP includes 407 native species and 50 exotic species. Significant taxa include one new species, *Phacelia sonoitensis*, found at SCSNA. Taxa new to the flora of Arizona include *Pennellia robinsonii* (SRSP), *Rhynchosia minima* (SCSNA), and *Sibara virginica* (SRSP). *Lilaeopsis schaffneriana* ssp. *recurva*, an endangered species, was found at SRSP. The floras of both SCSNA and SRSP are strongly Apachian in their affinities. Species found at SCSNA but not at SRSP have relatively greater affinities with the flora of the Sonoran Floristic Province, while those found at SRSP but not SCSNA have a greater affinity with the Great Plains.

RESUMEN

Sonoita Creek State Natural Area (SCSNA) y San Rafael State Park (SRSP) son los primeros parques naturales establecidos con fondos aportados por la Iniciativa de Herencia. Ambos lugares están en el condado de Santa Cruz, y ambos tienen comunidades ribereñas que son raras en el Suroeste árido. La vegetación del altiplano de SCSNA es un pastizal semidesértico y la de SRSP es un pastizal de las Grandes Llanuras. La flora de SCSNA incluye 525 especies indígenas y 36 especies exóticas; la de SRSP incluye 407 especies indígenas y 50 especies exóticas. Entre las plantas significativas se incluye una especies nueva, *Phacelia sonoitensis*, encontrada en SCSNA. Entre las especies nuevas para la flora de Arizona se incluyen *Pennellia robinsonii* (de SRSP), *Rhynchosia minima* (de SCSNA), y *Sibara virginica* (de SRSP). *Lilaeopsis schaffneriana* ssp. *recurva*, una especie en peligro fue encontrada en SRSP. Las floras de SCSNA y SRSP son fuertemente Apachianas en sus afinidades florísticas. Las especies encontradas en SCSNA pero no en SRSP tienen una afinidad más grande con la flora de la provincia florística de Sonora y las especies encontradas en SRSP pero no en SCSNA tienen una afinidad más grande con las Grandes Llanuras.

INTRODUCTION

Arizona voters passed the Heritage Initiative by a nearly two-thirds margin in the November 1990 general election. The Heritage Initiative allocates funds from the state lottery to Arizona State Parks and Arizona Game and Fish Department. Part of the funds for Arizona State Parks are designated for the acquisi-

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tion of "natural areas," defined in the initiative as "parcels of land or water that contain examples of unique natural terrestrial or aquatic ecosystems, rare species of plants and animals, or outstanding geologic or hydrologic features."

The first two acquisitions of large acreage for natural areas were both in Santa Cruz County, in southern Arizona, adjacent to the Mexican state of Sonora. The Sonoita Creek State Natural Area (SCSNA) in central Santa Cruz County was purchased in January 1994 for $2.8 million. The natural area feature justifying this purchase was Sonoita Creek and its associated gallery forest. Sonoita Creek is one of the few perennial or near perennial streams in southern Arizona. The SCSNA purchase included 4.5 km of perennial stream, along with 1,990 ha of watershed north of the creek, including intermittent wetlands in the streams of Fresno Canyon and Coal Mine Canyon. Sonoita Creek, Fresno Canyon, and Coal Mine Canyon provide habitat for the Gila topminnow (*Poeciliopsis occidentalis occidentalis*), a federally listed endangered species of fish.

The second acquisition was San Rafael State Park (SRSP) in extreme southeastern Santa Cruz County. The 8,900 ha San Rafael Land and Cattle Company, which included the San Rafael de la Zanja land grant, was purchased by the Nature Conservancy in December 1998 for $11 million. Arizona State Parks purchased the 1,440 ha of patented land along the Arizona-Sonora border along with a conservation easement on the entire ranch from the Nature Conservancy for $8.6 million in January 1999. Natural-area values cited for this purchase included the unique grassland communities of the San Rafael Valley and significant riparian and wetland habitat along the upper Santa Cruz River and at Sharp Spring and Heron Spring. The wetlands provide critical habitat for at least two endangered species, the Huachuca water umbel (*Lilaeopsis schaffneriana* ssp. *recurva*) and Gila topminnow.

Most of the watershed adjacent to SCSNA is mapped as semidesert grassland (Brown 1994), which is an extensive area in Arizona and adjacent New Mexico, Sonora, and Chihuahua varying in physiognomy and species composition. Grasses generally are not the dominant lifeform; instead there is a complex mixture of shrubs, small trees, succulents, rosette plants, and subshrubs, with the exact physiognomy and species composition determined by drought, the seasonal distribution of precipitation, periodic freezes, soils, grazing history, and fire (Burgess 1995). Burgess suggested the term "Apacherian mixed shrub savanna" for this complex mosaic of subtropical, semiarid vegetation found above desert and below oak savannas. In contrast, the San Rafael Valley is mapped as "Plains grassland" (Brown 1994) and is dominated by perennial bunchgrasses and oak savannas with very few leguminous trees and shrubs, subshrubs, cacti, or rosette succulents.

The primary objective of this study was to inventory the floras of these two natural area parks. The study also provided an opportunity to address a

second objective, to contrast the floras of semidesert grassland and Plains grasslands in southeastern Arizona.

STUDY AREAS

Table 1 lists the latitude, longitude, area, elevational relief, mean annual precipitation, and mean January and July temperatures for both SCSNA and SRSP. Below are brief descriptions of the major physical features, soils, vegetation, and recent history of each park.

Sonoita Creek State Natural Area

The SCSNA is located along and north of Sonoita Creek downstream from Patagonia Lake State Park. It is an area of rugged terrain with moderate to steep, rocky slopes. Fresno Canyon has an intermittent stream and extends from north to south across the center of the park. Coal Mine Canyon is an east-west trending tributary to Fresno Canyon; the north-facing slopes of Coal Mine Canyon provide the most mesic terrestrial habitats within the park. A spring in the northeast corner of the park appears to be permanently wet. Elevations range from 1,080 m near the junction of Sonoita Creek and Fresno Canyon in the southwest corner of the park, to 1,310 m at a point near the northern boundary. Figure 1 includes a map of SCSNA showing the major drainages; representative upland and riparian habitats are shown in Figure 2.

The exposed surface of the uplands adjacent to Sonoita Creek is that of the relatively impervious Nogales Formation, formed by the deposition of fine to coarse-grained alluvial fan deposits derived from pre-existing volcanic rocks. These deposits have been subject to subsequent folding and erosion, creating a complex topography of incised drainages and slopes of all aspects.

Upland soils at SCSNA include: (1) Graham soils, mostly gravelly or cobbly loams on more gentle slopes at lower elevations in canyons, usually at the base of tuffaceous mountains; (2) Lampshire-Graham-Rock Outcrop associations, shallow, cobbly loams on steeper slopes, and (3) Rock Outcrop-Lithic Haplustolls, cobbly loams found in the dissected terrain in the southeast corner of the park (Richardson et al. 1979). The soils on the flood plain of Sonoita Creek are deep, well-drained sandy loams of the Comoro Association.

The gallery forest along Sonoita Creek is dominated by cottonwood (*Populus fremontii*), ash (*Fraxinus velutina*), willows (*Salix gooddingii* and *S. bonplandiana*), and walnut (*Juglans major*). On terraces adjacent to the gallery forest there is a dense bosque of mesquite (*Prosopis velutina*), hackberry (*Celtis reticulata*), elderberry (*Sambucus mexicana*), and one large colony of tree of heaven (*Ailanthus altissima*).

The vegetation of the upland portions of SCSNA is mostly semidesert grassland, with small sections of oak (*Quercus emoryi* and *Q. oblongifolia*) savanna, mostly confined to the north-facing slope of Coal Mine Canyon. Species composition of the semidesert grassland is highly variable. The most common plants

TABLE 1. Physical features of Sonoita Creek State Natural Area (SCSNA) and San Rafael State Park (SRSP). Climate data are from Sellers et al. (1985); representative stations used are Nogales 6 N (31° 26' N, 110° 55' W, 1160 m elev.) for SCSNA and San Rafael Ranch (31° 21' N, 110° 37' W, 1446 m elev.) for SRSP.

Feature	SCSNA	SRSP
Latitude	31° 30' N	31° 21' N
Longitude	110° 54' W	110° 36' W
Area (ha)	1990	1440
Minimum elevation (m)	1080	1395
Maximum elevation (m)	1310	1475
Elevational relief (m)	230	80
Mean annual precipitation (mm)	430	440
Mean January temperate (°C)	7.4	5.6
Mean July temperature (°C)	25.9	23.5

include mesquite, hopbush (*Dodonaea viscosa*), coral-bean (*Erythrina flabelliformis*), beargrass (*Nolina microcarpa*), sotol (*Dasylirion wheeleri*), yucca (*Yucca thornberi*), shindagger (*Agave schottii*), acacia (*Acacia greggii*), mimosa (*Mimosa aculeaticarpa* var. *biuncifera*), and prickly pears (*Opuntia* spp.).

Prior to acquisition the site was primarily used for cattle grazing; trespass cattle were frequently observed during the floristic inventory. There is also evidence of historic small-scale mining activity on the site. The New Mexico and Arizona Railroad was constructed along Sonoita Creek during 1881–1882. Its bridges washed out on many occasions, and after a particularly devastating flood in 1929 the section of the line along Sonoita Creek was abandoned (Myrick 1975). Sections of the railroad bed are evident along most of the reach of the stream, usually at the edge of the floodplain.

San Rafael State Park

The SRSP is located in the San Rafael Valley, an isolated valley bounded on the west by the Patagonia Mountains, on the north by the Canelo Hills, and on the east by the Huachuca Mountains. SRSP occurs at the southern end of the valley adjacent to the US-Mexico international border. The San Rafael Valley is the headwaters of the Santa Cruz River, which runs north to south down the center of the valley. During the period of field work for this study the Santa Cruz River ran continuously where it crosses the SRSP, supporting a variety of wetland plant communities. Sharp Spring and Heron Spring are water courses flowing northeast to southwest into the Santa Cruz River; both have intermittent pools and support communities of wetland plants. Parker Canyon wash is a major drainage just entering SRSP in its southeastern corner. Figure 1 includes a map of SRSP showing the major drainages; representative upland and riparian habitats are shown in Figure 3.

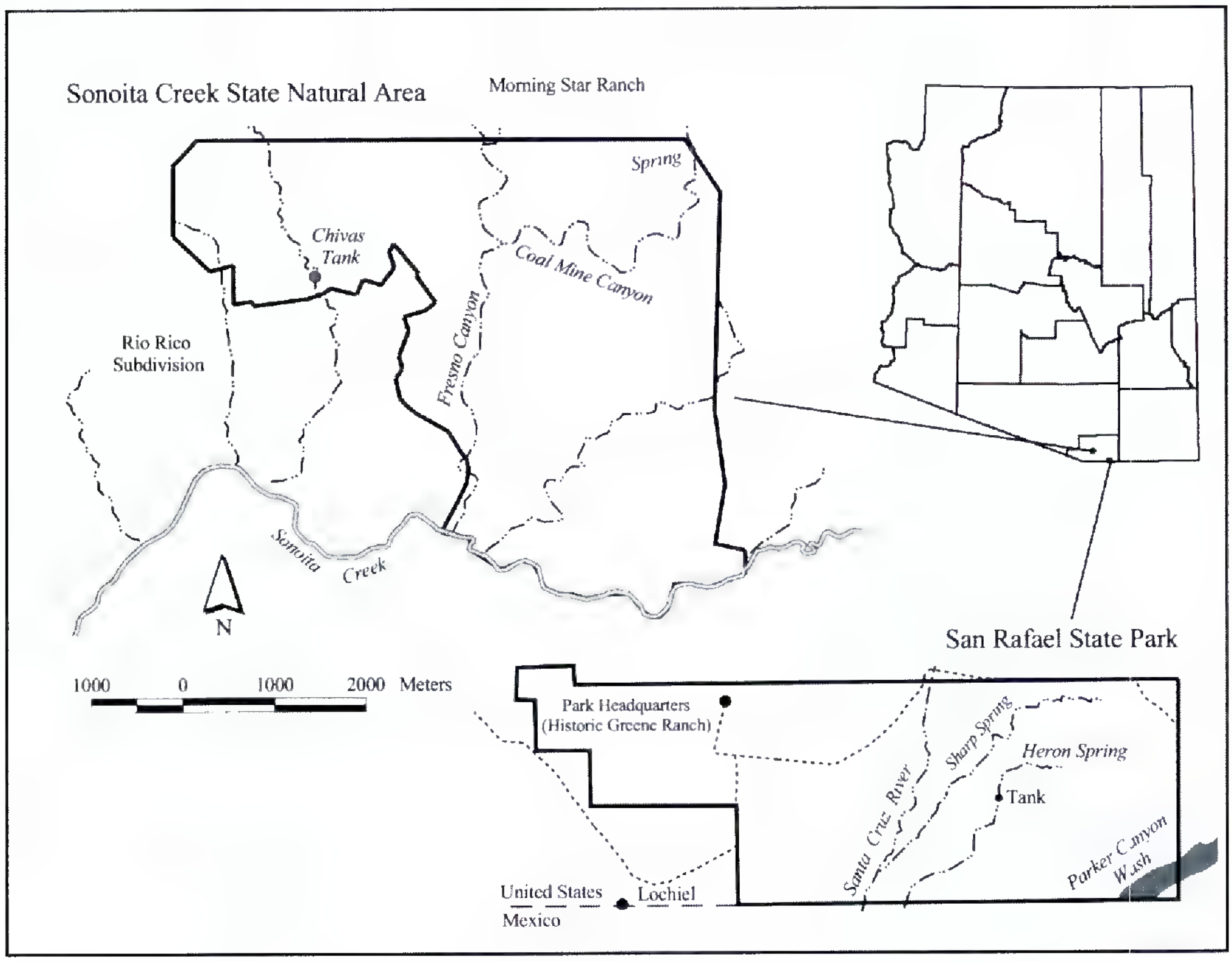


FIG. 1. Maps of Sonoita Creek State Natural Area, and San Rafael State Park, Santa Cruz County, Arizona.

Topography on the park consists mostly of low, gently sloping hills and shallow drainages. There are no bedrock outcrops. The Santa Cruz River is currently entrenched about 2 to 4 m within its floodplain, which averages about 0.5 km in width.

Soils along the floodplains of the Santa Cruz River, Sharp Spring, and Heron Spring are all mapped as Guest Soils, deep loams to clay loams (Richardson et al. 1979). The floodplain soils of Parker Canyon are gravelly sandy loams of the Grabe-Comoro complex. Most of the upland areas have gentle slopes with gravelly clay loams of the Bernardino-Hathaway Association, clay loams of the White House Association, or deep clay loams of the Pima Association. In the extreme southeast corner of SRSP, on the south side of Parker Canyon, there are calcareous gravelly sandy loams of the Hathaway Association on slopes of 20 to 50 percent steepness. The high clay content of most of the soils of the San Rafael Valley is probably associated with their resilience to high grazing pressure and resistance to invasion by shrubs and cacti.

The vegetation of the San Rafael Valley is primarily "Plains grassland", a true grassland dominated by grama grasses (*Bouteloua* spp.), wolftail (*Lycurus setosus*), cane bluestem (*Bothriochloa barbinodis*), Plains lovegrass (*Eragrostis*

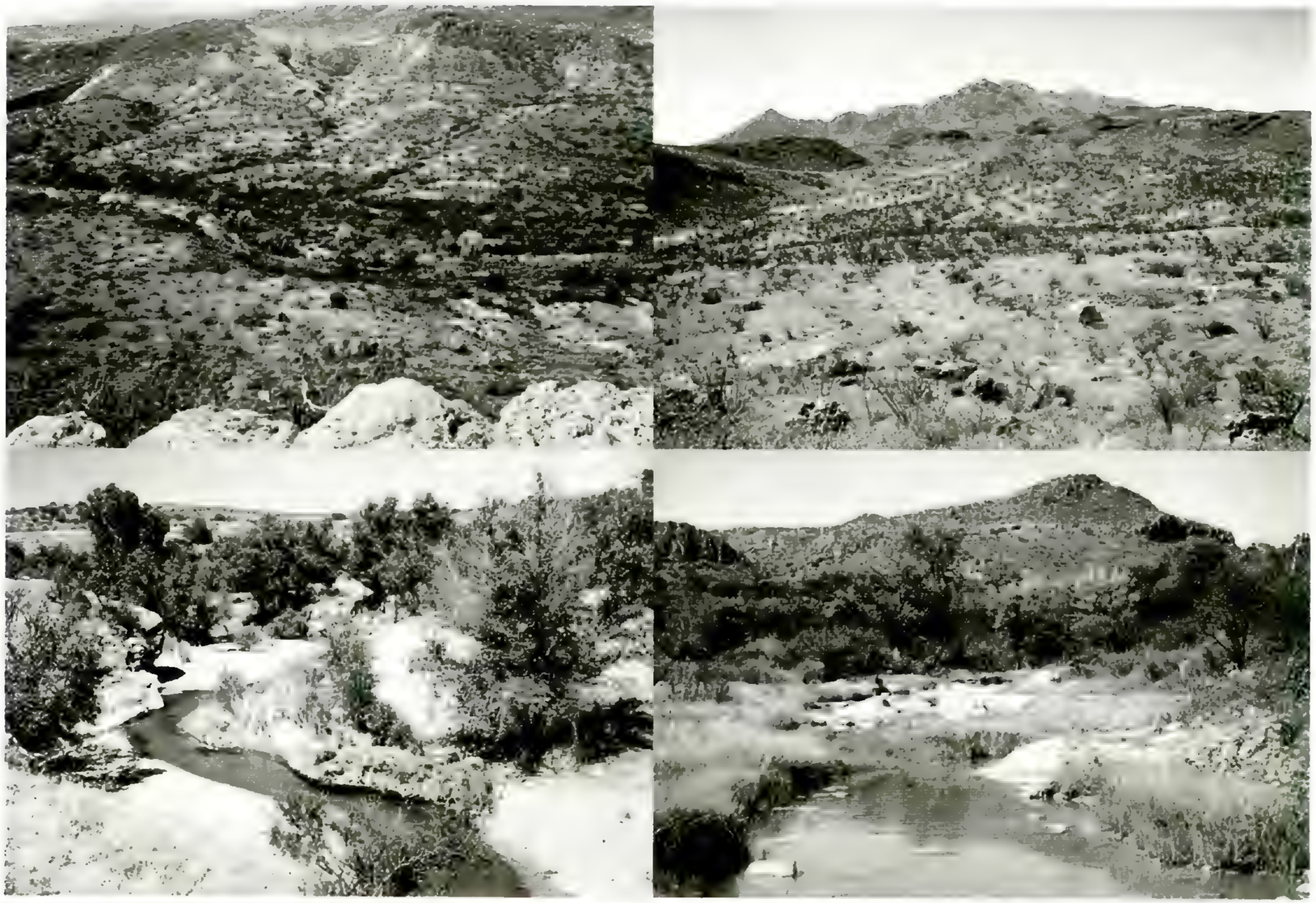


Fig. 2. Habitats at Sonoita Creek State Natural Area: semidesert grassland in Fresno Canyon, with ash trees (*Fraxinus velutina*) along stream and mesquites (*Prosopis velutina*), both on floodplain and uplands (upper left); semidesert grassland with abundant ocotillo (*Fouquieria splendens*) and mesquite (upper right); gallery forest of cottonwood (*Populus fremontii*) and willows (*Salix* spp.) along Sonoita Creek (lower left); and streamside communities in Fresno Canyon, dominated by flat sedges (*Cyperus* spp.) and spike rushes (*Eleocharis* spp.) (lower right).



Fig. 3. Habitats at San Rafael State Park: view of open grasslands of San Rafael Valley and SRSP from south side of Parker Canyon (upper left); Emory oak (*Quercus emoryi*) savanna (upper right); channel of Santa Cruz River, with dense rush (mostly *Juncus mexicanus*) and spike rush (*Eleocharis* spp.) adjacent to water, sacaton (*Sporobolus wrightii*), cottonwood, and willow on floodplain (lower left); and a portion of Sharp Spring with willows and *Bidens laevis* (lower right).

intermedia), Texas bluestem (*Schizachyrium cirratum*), spider grass (*Aristida ternipes*), and other perennial bunchgrasses. Broadleaf annual and perennial herbs are an important component of the vegetation, particularly species in the families Euphorbiaceae, Asteraceae, and Fabaceae. The abundance of non-grass components in the vegetation is likely due to intensive grazing in the last 150 years. Oak savannas are present in the northwestern portion of the park and along Parker Canyon wash.

There is an intermittent gallery forest along the Santa Cruz River, Sharp Spring, and Heron Spring composed mostly of cottonwood and willows (*Salix gooddingii*, *S. lasiolepis*, and *S. exilifolia*). Herbaceous vegetation along the Santa Cruz River is dominated by spikerushes (*Eleocharis* spp.) and true rushes (*Juncus* spp.). Grazing pressure in the wetlands along the Santa Cruz River, Sharp Spring, and Heron Spring appears to have been particularly heavy, and exotic species are locally abundant in these areas, particularly sweet clover (*Melilotus officinalis*), meadow fescue (*Festuca arundinacea*), and Kentucky blue grass (*Poa pratensis*). Most of the floodplain of the Santa Cruz River within SRSP was not cultivated, and this area contains an excellent example of sacaton (*Sporobolus wrightii*) grassland, a community that has disappeared from much of the Southwest due to lowering of water tables.

Hadley and Sheridan (1995) provided a detailed history of land use in the San Rafael Valley. The last 150 years have been a period of relatively intense cattle grazing. There have been numerous homesteads in the valley, and agriculture has been practiced on a limited scale on the Santa Cruz River floodplain. The San Rafael Ranch was the location for the filming of many movie westerns, including the musical *Oklahoma!*

METHODS

Field work was conducted from August, 2000, through November 2001. During the 17 months of the project a total of 62 trips were made, 34 to SCSNA and 28 to SRSP. The field work thus covered three growing seasons: the summer/fall of 2000 and 2001 and the spring of 2001. The winter of 2000–2001 was unusually wet, resulting in very productive collecting during spring of 2001. Since there was no direct vehicle access to the SCSNA, all of the collecting had to be done during long day-hikes. Plants were collected, mostly in duplicate, in plastic bags during the day and pressed either that same evening, or the following morning after allowing collections to rehydrate somewhat. At SRSP most collections could be made on shorter hikes and pressed while still in good condition.

A total of 1,286 specimens were collected, 689 from SCSNA and 597 from SRSP. Many trees, shrubs, and rosette succulents were not collected; rather their presence and distributions were recorded in field notes. Most cacti were identified in the field using Benson (1969). A few species were included in the flora based on earlier collections from the study areas in the herbarium at the

University of Arizona. Rick Gagnon, the ranger at SCSNA during the period of the field work, took hundreds of photographs of plants he encountered on that study site; a few species not encountered during the collection trips but photographed by Gagnon are also included in the flora.

In 2004, 1,064 ha adjacent to SCSNA, located to the northeast and upstream along the Coal Mine Creek watershed, was added to the park. This area, which is even more remote that the original acquisition, is likely to have additional taxa not found during the field work for this study.

Geographic affinities of the floras of SCSNA and SRSP were examined by mapping the percentage of native taxa found in 245 local floras from Mexico, the United States, and Canada, using a database compiled by the author. Such maps use contours (isolines of percentage overlap) to show in a concise way what proportion of the flora extends into neighboring geographic regions. Three maps were prepared: one for native species occurring in the floras of both SCSNA and SRSP, one for those occurring only at SCSNA, and one for those occurring only at SRSP.

RESULTS AND DISCUSSION

Floristic Summary

The total known flora for SCSNA is 561 species, 525 native and 36 exotic. For SRSP the total flora is 457 species, 407 native and 50 exotic. The percentage of exotic species in the flora of SCSNA is 6.4%, a typical value for floras in southeastern Arizona, but low for local floras in most other regions of the United States. Exotics at SRSP constitute 10.9% of the total flora. There are 277 species in common to the two sites, 252 native and 25 exotic. The floristic similarily (Otsuka's Index, based on native species only) between SCSNA and SRSP is 54.5%, a somewhat low value for two areas in such close proximity (Fig. 1), indicating significant differences in the floras of semidesert and Plains grassland communities.

There are 97 families and 354 genera in the flora of SCSNA, and 84 families and 274 genera at SRSP. The largest families in the two floras are listed in Table 2. The Asteraceae (composites), Poaceae (grasses), and Fabaceae (legumes) dominate in both floras, as they do in floras from most areas of the western United States. Even though the flora of SCSNA is larger than that of SRSP by more than 100 species, the number of Asteraceae are about the same and the number of Poaceae is actually larger at SRSP. The Poaceae also has the largest number of exotic species. The Euphorbiaceae is the fourth largest family at each site. One notable difference is the large number of Pteridaceae (ferns) at SCSNA, a family that is completely absent from the flora of SRSP. Ferns in the Pteridaceae generally grow on rock outcrops or rocky slopes, a habitat not found at SRSP. The largest genera in the flora at SCSNA are *Chamaesyce* (Euphorbiaceae, 11 species), *Bouteloua* (Poaceae, 8 species), *Cyperus* (Cyperaceae, 8 species), *Dalea*

TABLE 2. Largest families in tne floras of Sonoita Creek State Natural Area and San Rafael State Park: numbers of genera (G), native species (NS), exotic species (ES), and total species (TS).

Sonoita Creek State Natural Area					San Rafael State Park				
Family	**G**	**NS**	**ES**	**TS**	**Family**	**G**	**NS**	**ES**	**TS**
Asteraceae	59	84	3	87	Asteraceae	46	79	3	82
Poaceae	35	50	16	66	Poaceae	38	57	18	75
Fabaceae	31	51	2	53	Fabaceae	25	35	8	43
Euphorbiaceae	11	23	0	23	Euphorbiaceae	6	21	0	21
Scrophulariaceae	11	15	2	17	Brassicaceae	10	9	4	13
Brassicaceae	13	13	3	16	Solanaceae	6	11	0	11
Pteridaceae	7	13	0	13	Scrophulariaceae	7	9	1	10
Cactaceae	5	12	0	12	Cyperaceae	4	10	0	10
Cyperaceae	4	12	0	12	Chenopodiaceae	4	7	1	8
Convolvulaceae	3	11	0	11	Convolvulaceae	3	8	0	8
Malvaceae	8	11	0	11	Malvaceae	5	7	1	8
Solanaceae	7	10	1	11	Onagraceae	3	8	0	8

(Fabaceae, 8 species), *Boerhavia* (Nyctaginaceae, 7 species), *Ipomoea* (Convolvulaceae, 7 species), *Brickellia* (Asteraceae, 6 species), and *Phacelia* (Hydrophyllaceae, 6 species). At SRSP, the largest genera are *Chamaesyce* (9 species), *Bouteloua* (9 species), *Dalea* (7 species), *Asclepias* (Asclepiadaceae, 5 species), *Euphorbia s.s.* (Euphorbiaceae, 5 species), *Ipomoea* (5 species), *Machaeranthera* (Asteraceae, 5 species), and *Oenothera* (Onagraceae, 5 species).

The percentage of the total flora (natives + exotics) that are species found only in aquatic and wetland habitats is 13.6% for SCSNA and 21.8% for SRSP. For those species found at SRSP but not at SCSNA the percentage of wetland plants is 34.8%, indicating the relatively greater importance of wetland habitats at SRSP.

Significant Taxa

Ananthus squamulosa (A. Gray) King & H.E. Robinson (synonym *Brickellia squamulosa* A. Gray) (Asteraceae).—There is a relatively large population of this plant in Parker Canyon at SRSP. It is known in Arizona from only a few sites in the southeastern part of the state.

Argyrochosma incana (C. Presl) Windham (Pteridaceae).—This is a rare fern in the United States, known only from a limited area in southern Arizona. It is uncommon on rock outcrops at SCSNA.

Cirsium grahamii A. Gray (Asteraceae).—This large, attractive, uncommon thistle is restricted to ciénega habitats. It occurs in the Heron Spring drainage on SRSP.

Heterotheca rutteri (Rothrock) Shinners (Asteraceae).—This is a rare grassland plant with a narrow range in southeastern Arizona. It is locally abundant at many localities in grasslands at SRSP.

Lilaeopsis schaffneriana (Schltdl.) Coulter & Rose ssp. *recurva* (A.W. Hill) Affolter (Apiaceae).—This is a listed endangered species under the Endangered Species Act, the only such species so far documented from the floras of the two sites. It was previously recorded from Sharp Spring at SRSP. This species was not found at either Sharp or Heron springs, but a few populations along the Santa Cruz River were found at SRSP.

Pennellia robinsonii Rollins (Brassicaceae).—This species is new to the flora of Arizona and the United States. It differs from *P. micrantha* (A. Gray) Nieuwl., a woodland and forest species, in having shorter, wider siliques, dark purple sepals, and purplish-tinged petals (Rollins 1995). Rollins gives its range as restricted to the Mexican state of Chihuahua. The species is locally common in grasslands at SRSP.

Phacelia sonoitensis S.P. McLaughlin ined. (Hydrophyllaceae).—A previously unknown *Phacelia* was collected several times at SCSNA. The plant occurs on rock outcrops or on talus below rock outcrops; it was found at several widely scattered sites. It has a combination of characters that do not match any known *Phacelia* from the Southwest: pinnately compound leaves, narrowly spathulate sepals, and a capsule of several shallowly cymbiform seeds. A description of this proposed new taxon has been submitted to *Novon*.

Phyllanthus polygonoides Nutt. ex Spreng. (Euphorbiaceae).—This perennial herb is rare in Arizona, but is more common in Texas and Mexico. It is a rare plant at SCSNA in Fresno Canyon along the stream.

Potentilla wheeleri S. Watson (Rosaceae).—This species occurs at SRSP; it is known from relatively few locations in southeastern Arizona, all at much higher elevations in adjacent mountains or from rock walls in steep-sided mountain canyons. Its occurrence at such a low elevation is remarkable. It was common on a north-facing slope adjacent to Sharp Spring. Several other high-elevation taxa occurred at the same site, including *Thlaspi montana* var. *fendleri* and *Houstonia wrightii*.

Rhynchosia minima (L.) DC. (Fabaceae).—This is a new state record for Arizona. The species is common in northern Mexico and also occurs in the southeastern United States. It is rare at SCSNA, found once on a rocky slope above Coal Mine Canyon and once in Fresno Canyon.

Sibara virginica (Brassicaceae).—This is a new record for the state of Arizona; it was found on two occasions in dense sacaton stands adjacent to the Santa Cruz River in SRSP. *Sibara virginica* is a rather widespread species, and its status here as a native or exotic is not clear.

Tephrosia vicioides Schlect. (Fabaceae).—This perennial herb was previously overlooked in the flora of Arizona, and is only known from the state from just a few collections. It was found in SCSNA at a single location on loose, rocky soil in the center of the park.

Tillandsia recurvata (L.) L. (Bromeliaceae).—The epiphytic species is com-

mon in the tropics but is known in Arizona from just a few sites. It is locally common on junipers in narrow tributary canyons to Sonoita Creek at SCSNA.

Floristic Geography

Patterns of floristic affinity are illustrated by three maps (Fig. 4–6). These maps show the percentage of native species found in both parks (Fig. 4), found only at SCSNA (Fig. 5), and found only at SRSP (Fig. 6), which are present in each of 245 other local floras from North America. The average range size (number of local floras out of the sample of 245 local floras) for native species occurring in both SCSNA and SRSP is 26.2 floras. These taxa extend throughout the Apachian floristic area (McLaughlin 1989, 1992) of southeastern Arizona, northwestern Sonora, southeastern New Mexico, and northwestern Chihuahua, with clear affinities extending southeast into west Texas (Fig. 4). Ruderal species, wetland plants, and perennial grasses constitute a large proportion of the most widespread native species common to both parks.

Those native species recorded only for SCSNA are more narrowly distributed (mean range size = 15.6 floras) than those occurring in both parks. The average range size for the native species recorded only from SRSP is 25.2 local floras, similar to that for those species recorded for both floras. The higher proportion of wetland taxa among the native species found only at SRSP accounts in part for the greater average range size of these taxa. While the species found only at SCSNA are mostly Apachian in distribution, a relatively larger proportion extend into the Sonoran Floristic Province (McLaughlin 1992) of western Arizona, southeastern California, and throughout Sonora (Fig. 5). A much smaller percentage of those species recorded only from SRSP extend into the Sonoran Floristic Province, but a higher percentage extend southeast into the Madrean mixed-grass prairies (Bock & Bock 2000) of Chihuahua and Durango and east and northeast into the short-grass plains of eastern New Mexico and Colorado (Fig. 6).

The climates of SCSNA and SRSP are not that different (Table 1); in both areas precipitation occurring during the summer monsoon (July to September) accounts for 61% of the mean annual precipitation. The small differences in temperature and precipitation, however, are consistent with the relatively higher affinity of the warmer, drier SCSNA with the Sonoran Floristic Province, and for the higher affinity of the cooler, somewhat moister SRSP with the short-grass plains. The coarser textured, shallower soils of SCSNA may favor desert species while the deep clay soils of SRSP may favor species from the Great Plains. The floras of both parks, however, are overwhelmingly Apachian in their species composition.

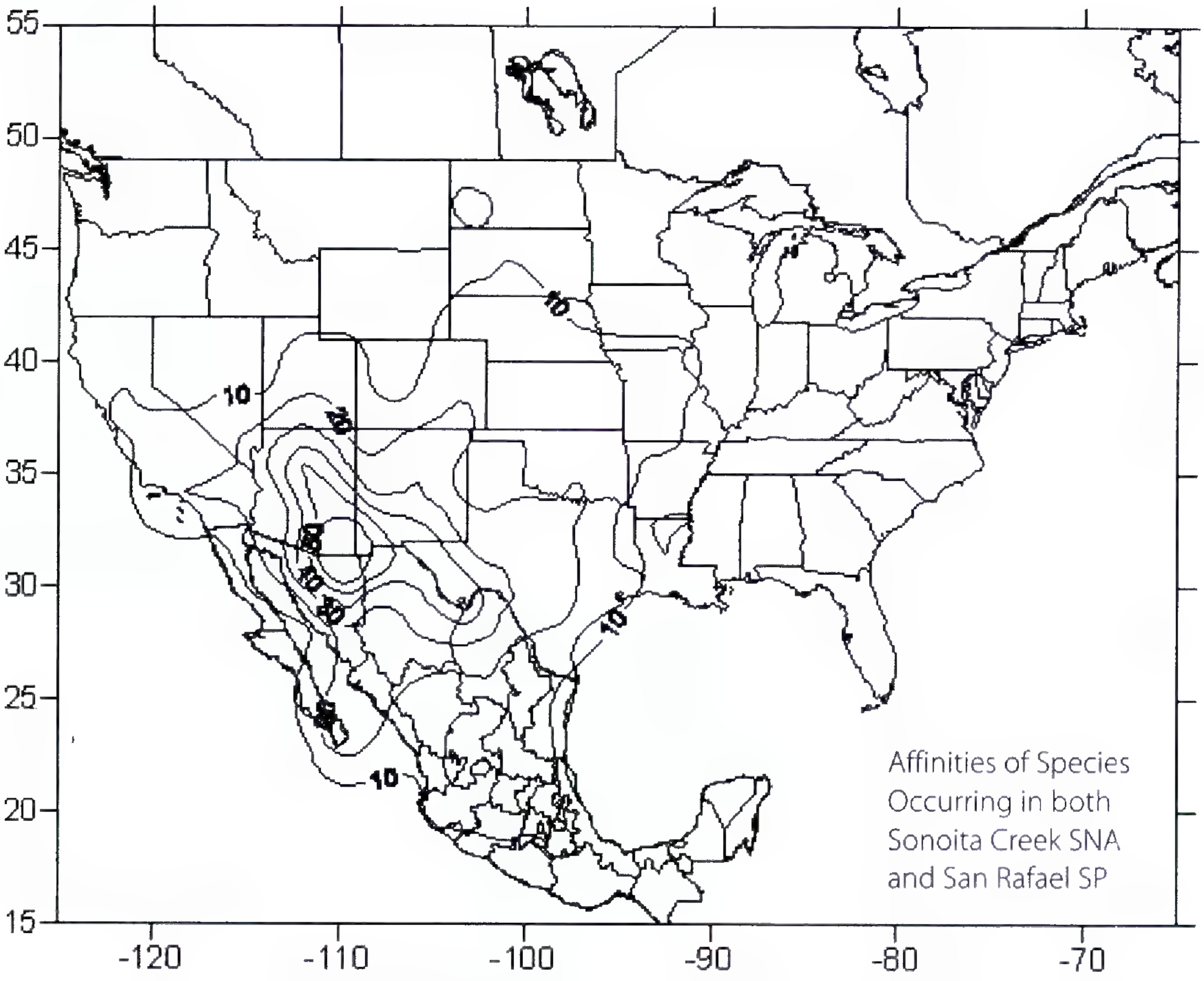


Fig. 4. Affinities of native species occurring in both Sonoita Creek State Natural Area and San Rafael State Park. Isolines represent the percentage of species in the floras of both parks that are found in other local floras from North America, based on a sample of 245 local floras.

ANNOTATED CHECKLIST

Nomenclature in the following checklist, with few exceptions, is based on Kartesz (1999). Nomenclature in Cactaceae follows Parfitt and Gibson (2003). Synonyms, when given, are for taxa listed under a different name in *Arizona Flora* (Kearney & Peebles 1960). Exotic species are preceded by an asterisk (*). Annotations for each species include: common name(s) when available, habit, collection numbers, and abundance and distribution for each study area (SC = Sonoita Creek State Natural Area; SR = San Rafael State Park). Spanish common names are those encountered in northeastern Sonora, as listed by White (1948). Common names and habits are not repeated for varieties with the same data. Voucher specimens were deposited at the University of Arizona Herbarium (ARIZ); duplicates were used to establish field herbaria for the two state parks. Several species, including most cacti and succulents, many trees and shrubs, and species not found in flower, were identified in the field and not vouchered. Unless otherwise indicated, collection numbers are those of the author.

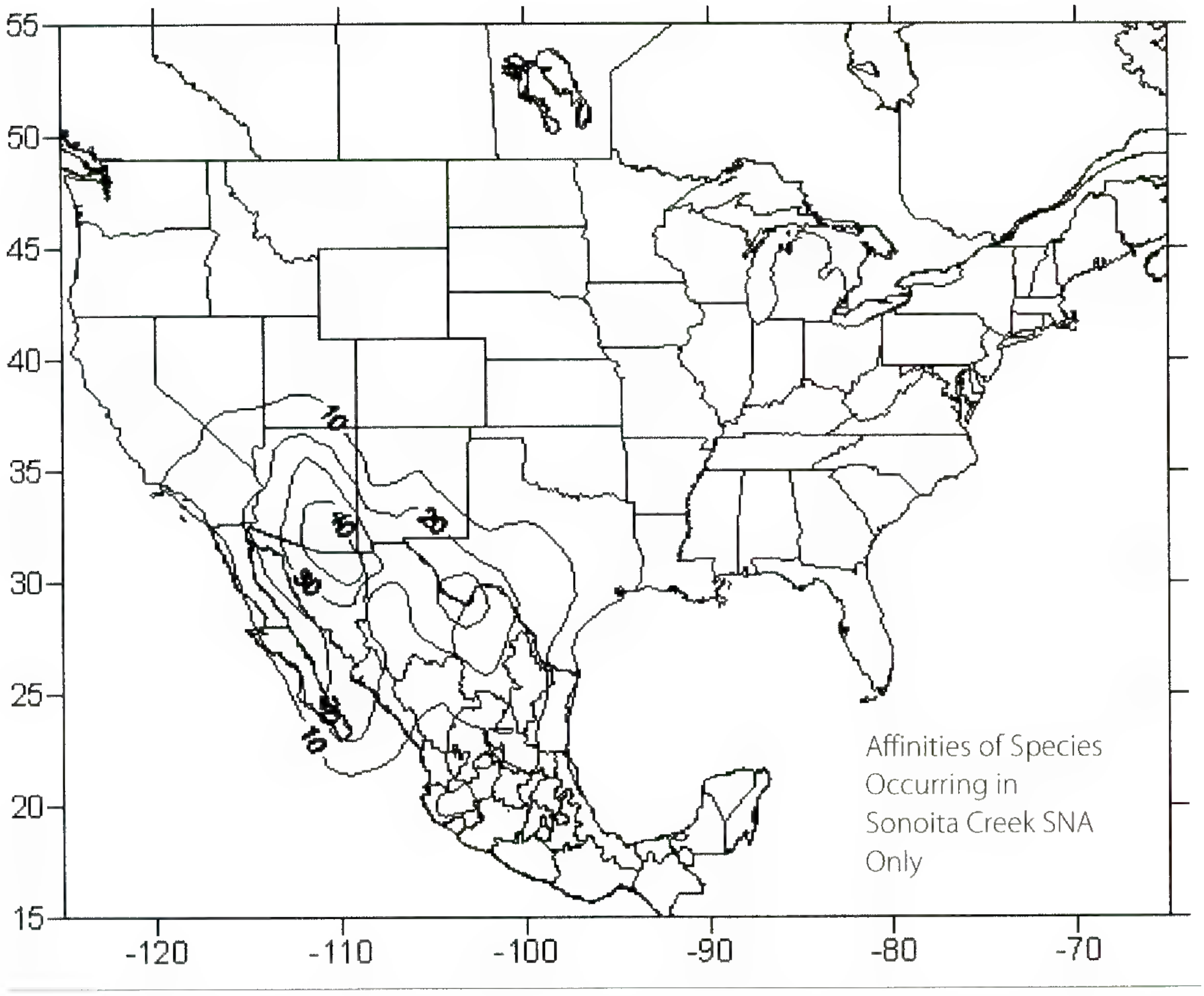


Fig. 5. Affinities of native species recorded only from Sonoita Creek State Natural Area (not found in San Rafael State Park). Isolines represent the percentage of species recorded only from SCSNA found in other local floras from North America, based on a sample of 245 local floras.

LYCOPODIOPHYTA

Selaginellaceae

Selaginella rupincola Underwood. Spike moss; herbaceous perennial. SC: *8357*; abundant on canyon slopes.

EQUISETOPHTYA

Equisetaceae

Equisetum × *ferrissii* Clute (pro sp.). Scouring rush; herbaceous perennial. SR: *8268*; occasional, Santa Cruz River bottom.

Equisetum laevigatum A. Braun. Scouring rush; herbaceous perennial. SC: *8745*; uncommon along Sonoita Creek. SR: *9432*; common, Santa Cruz River bottom.

POLYPODIOPHYTA

Azollaceae

Azolla mexicana C. Presl. Water fern; floating aquatic. SC: *9330*; rare in pools along Sonoita Creek. SR: *8784*, uncommon, Sharp Spring.

Marsileaceae

Marsilea mollis B. L. Robinson & Fernald. Pepperwort; herbaceous perennial. SR: *Niles 698* (ARIZ); collected last in 1965 from a pool adjacent to the Santa Cruz River.

Marsilea vestita Hook. & Grev. [*M. mucronata* A. Br.]. Clover fern; herbaceous perennial. SC: *8498, 8532*; uncommon along streams in Fresno and Coal Mine Canyons. SR: *Van Devender 84-443* (ARIZ); collected last in 1984 from a pool adjacent to the Santa Cruz River.

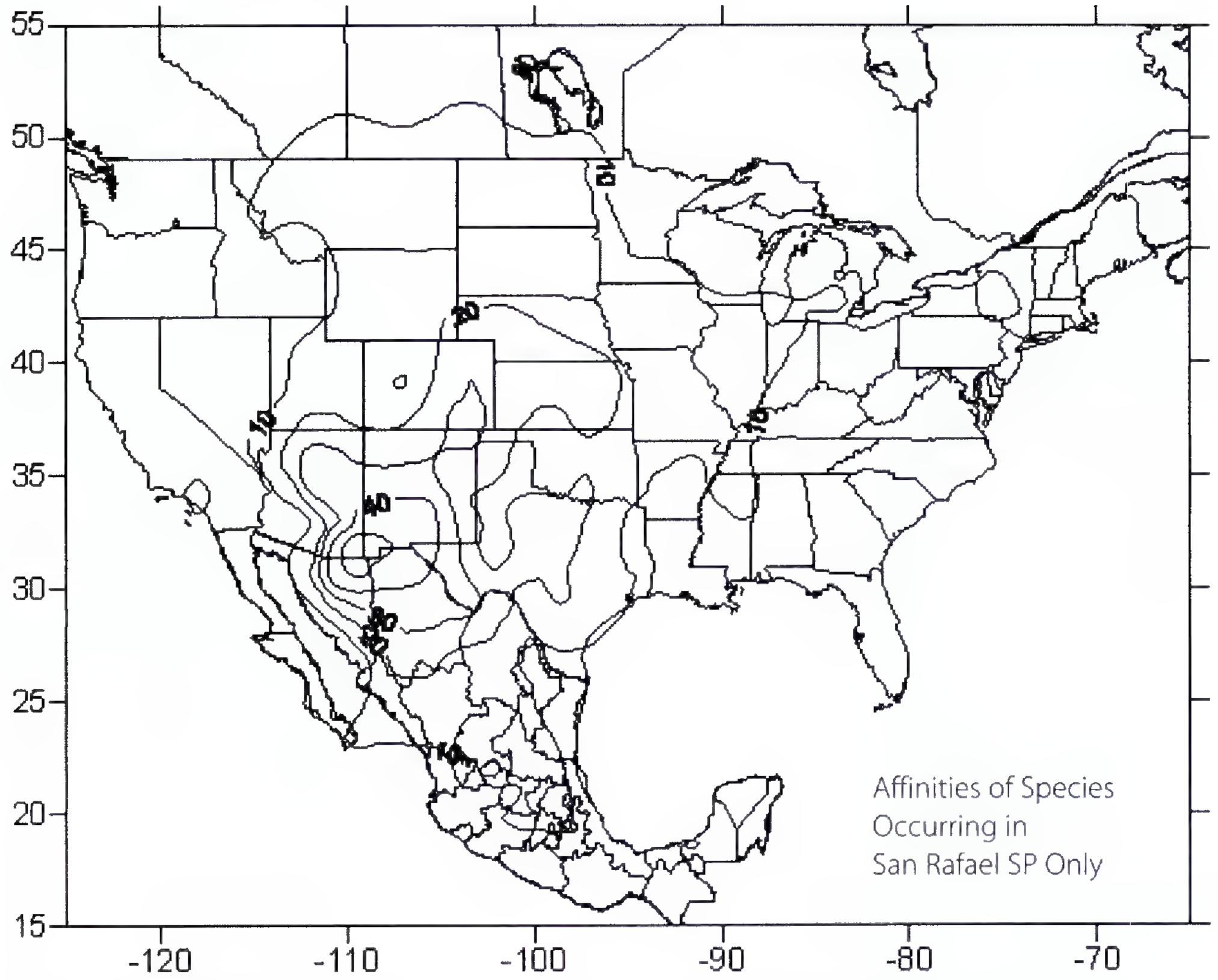


Fig. 6. Affinities of native species recorded only from San Rafael State Park (not found in Sonoita Creek State Natural Area). Isolines represent the percentage of species recorded only from SRSP found in other local floras from North America, based on a sample of 245 local floras. Compare with Fig. 5.

Pteridaceae

Adiantum capillus-veneris L. Maidenhair fern; herbaceous perennial. SC: *9419*; below rock overhangs, west park boundary on south side of Sonoita Creek.

Argyrochosma incana (K. Presl) Windham. Cloak fern; herbaceous perennial. SC: *8401*; uncommon on rock walls.

Argyrochosma limitanea (Maxon) Windham ssp. *limitanea* [*Pellaea limitanea* (Maxon) Morton]. Cloak fern; herbaceous perennial. SC: *8806*; uncommon on rock walls.

Astrolepis integerrima (Hook.) D.M. Benham & Windham [*Notholaena sinuata* (Lagasca) Kaulf. var. *integerrima* Hook.]. *Canahuala*; herbaceous perennial. SC: *8360, 8454*; uncommon on rock walls.

Astrolepis sinuata (Lagasca ex Swartz) D.M. Benham & Windham ssp. *sinuata* [*Notholaena sinuata* (Lagasca) Kaulf. var. *sinuata*]. *Canahuala*; herbaceous perennial. SC: *8406*; common on rocky slopes and rock walls.

Bommeria hispida (Mett. ex Kuhn) Underwood. Hairy bommeria; herbaceous perennial. SC: *8400*; uncommon, mostly below oaks.

Cheilanthes eatonii Baker. Lip fern; herbaceous perennial. SC: *9677*; rare, canyon walls.

Cheilanthes lindheimeri Hook. Fairy swords; herbaceous perennial. SC: *8380*; common on rocky slopes and rock walls.

Cheilanthes wrightii Hook. Wright's lip fern; herbaceous perennial. SC: *8416, 8820, 8871*; common on rocky slopes.

Notholaena grayi Davenport. Cloak fern; herba-

ceous perennial. SC: *8351*; uncommon on rock walls.

Notholaena standleyi Maxon. Cloak fern; herbaceous perennial. SC: *8410, 8822*; uncommon on rock walls.

Pellaea intermedia Mett. ex Kuhn. Cliff brake; herbaceous perennial. SC: *6846, 9217*; rare on rock walls.

Pellaea wrightiana Hook. Cliff brake; herbaceous perennial. SC: *8818, 8933, 9217*; rare on rock walls.

PINOPHYTA

Cupressaceae

Juniperus coahuilensis (Martinez) Gaussen ex R.P. Adams [*J. monosperma* (Torr.) Little *sensu* Kearney and Peebles (1960), in part]. Juniper, *huata, táscate, táscale*; small tree. SC: *9408*; common in canyons, uplands.

Juniperus deppeana Steud. Alligator juniper, *huata, táscale, táscate*; small tree. SR: *9392*; uncommon, grasslands east of Santa Cruz River.

MAGNOLIOPHYTA: MAGNOLIOPSIDA

Acanthaceae

Anisacanthus thurberi (Torr.) A. Gray. Desert honeysuckle; large shrub. SC: *9280*; common in canyons.

Carlowrightia arizonica A. Gray. Herbaceous perennial. SC: *9291, 9297*; uncommon in mesquite grasslands.

Dicliptera resupinata (Vahl) Juss. Herbaceous perennial. SC: *8734*; common in shade of gallery forests along Sonoita Creek.

Dyschoriste decumbens (A. Gray) Kuntze. Herbaceous perennial. SR: *8287*; common, grasslands.

Elytraria imbricata (Vahl) Pers. Purple scaly stem, *cordoncillo;* herbaceous perennial. SC: *8369*; common, canyons, rocky slopes.

Tetramerium nervosum Nees [*T. hispidum* Nees]. Herbaceous perennial. SC: *8348, 9232*; uncommon, mostly in canyon bottoms.

Aizoaceae

Trianthema portulacastrum L. Horse purslane; summer annual. SC: *8419*; occasional in overgrazed sites. SR: *8791*; uncommon, sacaton stands.

Amaranthaceae

Alternanthera pungens Kunth [*A. repens* (L.) Kuntze]. Khakiweed; mat-forming herbaceous perennial. SR: *8712*; occasional, grasslands.

Amaranthus palmeri S. Watson. Palmer's amaranth, *bledo, quelite*; summer annual. SC: *8352, 8453*; common, canyons, overgrazed sites. SR: *8253, 8270*; common, mostly along drainages.

Amaranthus torreyi (A. Gray) Benth. ex S. Watson. Torr.'s amaranth; summer annual. SC: *8392, 8422*; uncommon, mostly in canyons.

Froelichia arizonica Thornber ex Standley. Snake cotton; herbaceous perennial. SC: *8809*; rare, found once in Fresno Canyon.

Gomphrena caespitosa Torr. Globe amaranth; herbaceous perennial. SC: *9225B*; occasional, grasslands. SR: *9243*; common, grasslands.

Gomphrena nitida Rothrock. Globe amaranth; herbaceous perennial. SC: *8481*; common, grasslands. SR: *8283, 8310*; occasional, grasslands.

Gomphrena sonorae Torr. Globe amaranth; herbaceous perennial. SC: *8370*; common, grasslands.

Guilleminea densa (Humb. & Bonpl. ex Willd.) Moq. [*Brayulinea densa* (Humb. & Bonpl.) Small]. Herbaceous perennial. SC: *8415*; occasional, grasslands. SR: *8569*; common, grasslands.

Iresine heterophylla Standley. Bloodleaf; herbaceous perennial. SC: *8751*; rare, canyons.

Anacardiaceae

Rhus trilobata Nutt. var. *anisophylla* (Greene) Jepson. Sumac, squawbush, *lima*; shrub. SR: *9630*; rare, oak woodland adjacent to Parker Canyon.

Rhus trilobata Nutt. var. *pilosissima* Engelm. Shrub. SC: *9209*; uncommon, canyons.

Rhus virens Lindheimer ex A. Gray var. *choriophylla* (Wooton & Standley) L. Benson [*R. choriophylla* Wooton & Standley]. *Lima*; shrub. SC: rare, canyons.

Toxicodendron rydbergii (Small ex Rydberg) Greene [*Rhus radicans* L. var. *rydbergii* (Small) Rehder]. Poison ivy, *hiedra*; woody vine. SC: *9420*; uncommon, canyons.

Apiaceae

Berula erecta (Huds.) Coville. Water parsnip; herbaceous perennial. SR: *8276*; common, springs.

Bowlesia incana Ruiz & Pavón. Hairy bowlesia; winter annual. SC: *8875*; abundant, especially below mesquites.

**Conium maculatum* L. Poison hemlock; biennial. SC: *9474*; rare, along Sonoita Creek.

Daucus pusillus Michx. American carrot; winter annual. SC: *8926*; common on rocky uplands.

Eryngium heterophyllum Engelm. Mexican thist e; herbaceous perennial. SR: *8315*; occasional, grasslands.

Hydrocotyle ranunculoides L. f. Water pennywort; aquatic herbaceous perennial. SC: *8496*; rare, pools in Fresno and Coal Mine Canyons. SR: *8787*; occasional; Santa Cruz River bottom.

Lilaeopsis schaffneriana (Schltdl.) J. M. Coulter & Rose var. *recurva* (A.W. Hill) Affolter. Huachuca water umbel; inconspicuous herbaceous perennial. SR: *9434*; uncommon, shallow water along Santa Cruz River.

Lomatium nevadense (S. Watson) J. M. Coulter & Rose var. *parishii* (J. M. Coulter & Rose) Jepson. Indian root; herbaceous perennial. SC: *8843*, *9084*; rare, mesquite grasslands.

Spermolepis echinata (Nutt. ex DC.) Heller. Scale seed; winter annual. SC: *8903*; occasional, canyons and uplands. SR: *9104*; uncommon, grasslands.

Yabea microcarpa (Hook. & Arn.) K.-Pol [*Caucalis microcarpa* Hook. & Arn.]. Winter annual. SC: *9024*, *9025*; locally abundant, north-facing slopes in oak savanna.

Apocynaceae

Apocynum cannabinum L. Dogbane, Indian hemp; herbaceous perennial. SC: *9360*; rare, one population in Coal Mine Canyon.

Haplophyton crooksii (L. Benson) L. Benson. Cockroach plant, *hierba de la cucuracha*; herbaceous perennial. SC: *9500*, *E.A. Lewis 012*; rare, rocky slopes, canyons.

Telosiphonia brachysiphon (Torr.) Henrickson [*Macrosiphonia brachysiphon* (Torr.) A. Gray]. Rock trumpet; herbaceous perennial. SC: *8523*, *E.A. Lewis 013*, locally abundant on rocky slopes. SR: *9579*; rare, grasslands.

Araliaceae

Aralia humilis Cav. *Tepetate*; shrub. SC: *9703*; rare, rocky north-facing slope.

Aristolochiaceae

Aristolochia watsonii Wooton & Standley. Indian root; herbaceous perennial. SC: *8907*, *9550*; uncommon and infrequent, mostly on rock walls.

Asclepiadaceae

Asclepias asperula (Dcne.) Woodson ssp. *asperula* [*A. capricornu* Woodson *sensu* Kearny and Peebles (1960)]. Antelope horns; herbaceous perennial. SC: *9220*; rare, grasslands. SR: *9397*; uncommon, grasslands.

Asclepias involucrata Engelm. Milkweed; herbaceous perennial. SR: *9154*; uncommon, grasslands.

Asclepias linaria Cav. Milkweed; shrub. SC: *8437*; rare, ridgetops.

Asclepias nummularia Torr. Milkweed, *yerba de cuerve*; herbaceous perennial. SC: *9279*; rare, grasslands, rocky slopes. SR: *9394*; occasional, grasslands.

Asclepias nyctaginifolia A. Gray. Four o'clock milkweed; herbaceous perennial. SC: *9551*; rare, canyons, rocky slopes. SR: uncommon, grasslands.

Asclepias subverticillata (A. Gray) Vail. Poison milkweed, western whorled milkweed; herbaceous perennial. SR: *8239*; common, grasslands, Sharp Spring drainage.

Asclepias tuberosa L. ssp. *interior* Woodson. Butterfly weed, pleurisy root, orange milkweed; herbaceous perennial. SR: *8280*; uncommon, grasslands.

Funastrum cynanchoides Dcne. ssp. *heterophyllum* (Engelm. ex Torr.) Kartesz [*F. heterophyllum* (Engelm.) Standley]. Climbing milkweed; herbaceous perennial vine. SC: *9292*; rare, canyons. SR: *8585*; uncommon, on shrubs in grasslands.

Asteraceae

Acourtia thurberi (A. Gray) Reveal & King [*Perezia thurberi* A. Gray]. Large herbaceous perennial. SC: *8771*; rare, canyons.

Acourtia wrightii (A. Gray) Reveal & King [*Perezia wrightii* A. Gray]. Brownfoot; herbaceous perennial. SC: *8922*; rare, uplands.

Ambrosia confertiflora DC. [*Franseria confertiflora* (DC.) Rydberg]. Slimleaf bursage; herbaceous perennial. SR: *8594*; abundant, grasslands.

Ambrosia psilostachya DC. Western ragweed; herbaceous perennial. SR: *8599*; locally abundant, grasslands, Parker Canyon.

Ambrosia trifida L. var. *texana* Scheele [*A. aptera* DC.]. Ragweed, *chuchuni*; herbaceous perennial. SC: *8656*; abundant along Sonoita Creek. SR: *8302*; common, roadsides, low areas, Santa Cruz River bottom.

Ananthus squamulosa (A. Gray) King & H.E. Robinson [*Brickellia squamulosa* A. Gray]. Herbaceous perennial. SR: *9728*, *9736*; locally common, Parker Canyon.

Antheropeas lanosum (A. Gray) Rydberg. [*Eriophyllum lanosum* A. Gray]. Woolly-daisy; winter annual. SC: *8920A*, *9076*; common in mesquite grasslands.

Artemisia campestris L. ssp. *borealis* (Pallas) Hall & Clements var. *scouleriana* (Hook.) Cronq. [*A. pacifica* Nutt.]. Wormwood; herbaceous perennial. SR: *9623*; rare, Parker Canyon.

Artemisia dracunculus L. [*A. dracunculoides* Pursh]. False tarragon; herbaceous perennial. SC: *9707*; rare, north-facing slope in Coal Mine Canyon.

Artemisia ludoviciana Nutt. ssp. *albula* (Wooton) Keck. Wormwood; herbaceous perennial. SC: *8673*; common, north-facing slopes. SR: occasional, oak woodlands and savannas.

Artemisia ludoviciana Nutt. ssp. *sulcata* (Rydberg) Keck. SR: *8728A*; occasional, oak woodlands and savannas.

Baccharis bigelovii A. Gray. Shrub. SR: *9694*, *9726*; rare, oak woodland adjacent to Parker Canyon.

Baccharis pteronioides DC. *Yerba de pasmo*; small shrub. SC: *9365*; common in grasslands. SR: *9376*; common, grasslands.

Baccharis salicifolia (Ruiz & Pavón) Pers. [*B. glutinosa* Pers.]. Seep willow, *batamote, jarilla*; shrub. SC: *9651*; occasional along Sonoita Creek, Fresno Canyon. SR: *9660*; occasional, Parker Canyon.

Baccharis sarothroides A. Gray. Desert broom, *romerillo*; shrub. SC: *8811*; common, canyons. SR: *9723*; uncommon, mostly roadsides.

Baccharis thesioides Kunth. Shrub. SC: *8759*; rare, canyon walls, north-facing slopes.

Bahia absinthifolia Benth. var. *dealbata* (A. Gray) A. Gray. Perennial herb. SC: *9271*; rare, rocky slopes.

Baileya multiradiata Harvey & A. Gray ex A. Gray. Desert marigold; perennial herb. SC: *9142*; rare, grasslands.

Barkleyanthus salicifolius (Kunth) H.E. Robinson & Brett. [*Senecio salignus* DC.] Shrub. SC: *8914*; common in gallery forest along Sonoita Creek.

Bebbia juncea (Benth.) Greene var. *aspera* Greene. Sweet bush; shrub. SC: *9414*; rare, rocky uplands.

Berlandiera lyrata Benth. Chocolate flower, *yerba de la víbora*; herbaceous perennial. SR: *9160*; occasional, grasslands, roadsides.

Bidens aurea (Ait.) Sherff. Bur marigold; perennial herb. SC: *8652*, *8773*, *9719*; uncommon, along streams.

Bidens bigelovii A. Gray. Beggar ticks, Spanish needles; summer annual. SR: *9619*, *9692*; uncommon, Parker Canyon.

Bidens ferulaefolia (Jacq.) DC. Beggar ticks, Spanish needles; annual. SR: *8320*; occasional, springs.

Bidens laevis (L.) B.S.P. Bur marigold; herbaceous perennial. SR: *8781*, *9573*; common, springs, Santa Cruz River bottom.

Bidens leptocephala Sherff. Beggar ticks, Spanish needles; summer annual. SC: *8356*; abundant, canyons, oak woodlands. SR; *8700*, common below oaks.

Brickellia amplexicaulis B. L. Robinson var. *amplexicaulis*. Perennial herb. SC: *8763*; rare, upper Fresno Canyon.

Brickellia baccharidea A. Gray. Shrub. SC: *9680*; rare, Fresno Canyon.

Brickellia betonicifolia A. Gray. Herbaceous perennial. SR: *9699*; rare, oak savanna.

Brickellia californica (Torr. & A. Gray) A. Gray var. *californica*. Shrub. SC: *8807*; uncommon, canyons.

Brickellia coulteri A. Gray. Perennial herb. SC: *8837*; rare, canyons.

Brickellia eupatorioides (L.) Shinners var. *chlorolepis* (Wooton & Standley) B. L. Turner [*Kuhnia rosmarinifolia* Vent. var. *chlorolepis* (Wooton & Standley) Blake]. Herbaceous perennial. SR: *8563*; common, grasslands.

Brickellia floribunda A. Gray. Robust perennial herb. SC: uncommon, along Sonoita Creek. SR: *9717*; common, Parker Canyon.

Brickellia venosa (Wooton & Standley) B. L. Robinson. Herbaceous perennial. SC: *8676B*, *9720*; occasional, canyons.

Calycoseris wrightii A. Gray. Tackstem; winter annual. SC: *9074*; rare, uplands.

Carminatia tenuiflora DC. Plume weed; summer annual. SC: *8657*; rare, shaded canyon walls.

Carphochaete bigelovii A. Gray. Bristlehead; low shrub. SC: *9283*; rare, rocky uplands. SR: *9102*; rare, oak woodland adjacent to Parker Canyon.

Chaetopappa ericoides (Torr.) Nesom [*Aster arenosus* (Heller) Blake, *A. hirtifolius* Blake]. White aster, rose heath; herbaceous perennial. SC: *9029*; occasional, mesquite grasslands. SR: *9377*; common, grasslands.

Cirsium grahami A. Gray. Thistle; large biennial. SR: *8282*; uncommon, springs.

Cirsium neomexicanum A. Gray. Thistle; biennial. SC: *9136*; occasional, mostly in canyons. SR: occasional, grasslands.

Cirsium ochrocentrum A. Gray. Yellow spine thistle; biennial. SR: *9368*; common, grasslands.

Conyza canadensis (L.) Cronq. [*Erigeron canadensis* L.]. Horseweed; summer annual. SC: *8658*; common, canyons. SR: *8696*; locally abundant, grasslands.

Cosmos parviflorus (Jacq.) Pers. Cosmos; summer annual. SR: *9714*; rare, Parker Canyon.

Eclipta prostrata (L.) L. [*E. alba* (L.) Hassk.]. *Yerba de tajo*; summer annual. SC: *9669*; rare, wet ground along Sonoita Creek.

Ericameria laricifolia (A. Gray) Shinners [*Aplopappus laricifolius* A. Gray]. Turpentine bush; shrub. SC: *9730*; common, north-facing slopes, ridgetops.

Ericameria nauseosa (Pallas ex Pursh) Nesom & Baird ssp. *nauseosa* var. *latisquamea* (A. Gray) Nesom & Baird [*Chrysothamnus nauseosus* (Pallas ex Pursh) Britt. ssp. *latisquameus* (A. Gray) Hall & Clements]. Rabbitbrush; shrub. SR: *9724*; abundant, Parker Canyon.

Erigeron ariosolus Nesom [*E. divergens* Torr. & A. Gray, in part]. Fleabane; annual or herbaceous perennial. SR: *8237, 8279, 8549B*; common, grasslands.

Erigeron colomexicanus A. Nelson [*E. divergens* Torr. & A. Gray, in part]. Fleabane; herbaceous perennial. SC: *9211*; uncommon, along stream, Fresno Canyon.

Erigeron divergens Torr. & A. Gray. Spreading fleabane; annual or herbaceous perennial. SC: *8446, 8916, 9082, 9224*; common, canyons and uplands. SR: *9100, 9602*; common, grasslands.

Erigeron flagellaris A. Gray. Fleabane; herbaceous perennial. SR: *9246, 9252, 9310*; common, grasslands and sacaton flats.

Erigeron oreophilus Greenm. Fleabane; herbaceous perennial. SC: *8477*; uncommon, canyons, below trees.

Evax verna Raf. var. *verna* [*E. multicaulis* DC. var. *multicaulis*]. Rabbit tobacco, cotton rose; winter annual. SC: *9073*; common, mesquite grasslands. SR: *9110, 9250*; occasional, grasslands.

Filago californica Nutt. *Yerba impia*; winter annual. SC: *9014B, 9017, 9087*; common, canyons and slopes.

Fleischmannia pycnocephala (Less.) King & H.E. Robinson [*Eupatorium pycnocephalum* Less.]. Thoroughwort; herbaceous perennial. SC: *8774*; rare, north-facing slopes.

Gaillardia pinnatifida Torr. Blanket flower; herbaceous perennial. SR: *8726*; occasional, grasslands and roadsides.

Gamochaeta purpurea (L.) Cabrera [*Gnaphalium purpureum* L.]. Cudweed; winter annual. SC: *9014A, 9026*; abundant, mesquite grasslands. SR: *9057*; common, grasslands.

Guardiola platyphylla A. Gray. Shrub. SC: *9552*; uncommon, Fresno Canyon.

Gutierrezia microcephala (DC.) A. Gray. Snakeweed; subshrub. SC: *8772*; common in uplands.

Helenium thurberi A. Gray. Sneezeweed; annual. SC: *8659, 8741*; uncommon along streams.

Helianthus annuus L. Common sunflower, *girasol*; tall summer annual. SC: *9653*; occasional, along Sonoita Creek. SR: *8303*; abundant, low areas, roadsides.

Helianthus petiolaris Nutt. Sunflower, *girasol*; summer annual. SC: *9683*; rare, canyons. SR: *8731*; common, Parker Canyon.

Heliomeris longifolia (Robinson & Greenm.) Cockerell var. *annua* (M.E. Jones) Yates [*Viguiera annua* (Jones) Blake]. Annual goldeneye; late summer annual. SC: *8819*; common, uplands. SR: *9688*; abundant, grasslands.

Heliomeris multiflora Nutt. [*Viguiera multiflora* (Nutt.) Blake]. Golden eye; herbaceous perennial. SR; *8736*, uncommon, springs.

Heterosperma pinnatum Cav. Summer annual. SC: *8540*; uncommon, north-facing slope, Coal Mine Canyon. SR; *8590*, common, Parker Canyon.

Heterotheca rutteri (Rothrock) Shinners. Herbaceous perennial. SR: *8264*; locally common, grasslands.

Heterotheca subaxillaris (Lam.) Britton & Rusby. Telegraph plant; herbaceous perennial. SC: *8757*; common, along Sonoita Creek, canyons. SR: *8553*; common, grasslands and roadsides.

Hymenoclea monogyra Torr. & A. Gray ex A. Gray. Burrobush; shrub. SC: *8812*; common along Sonoita Creek. SR: *9693*; rare, Parker Canyon.

Hymenothrix wislizenii A. Gray. Summer annual. SR: *8583*; occasional, grasslands.

Hymenothrix wrightii A. Gray. Herbaceous perennial. SC: *8768*, *9732*; uncommon, Fresno Canyon.

Isocoma tenuisecta Greene [*Aplopappus tenuisectus* (Greene) Blake]. Burroweed; subshrub. SC: *9707*; common, mesquite grasslands. SR: *9713*; uncommon, grasslands.

Koanophyllon solidaginifolium (A. Gray) King & H.E. Robinson [*Eupatorium soldaginifolium* A. Gray]. Thoroughwort; herbaceous perennial. SC: *9506*, *9731*; rare, north-facing slopes.

**Lactuca serriola* L. Prickly lettuce, wild lettuce; annual. SC: *9467*; occasional, canyons, rocky slopes. SR: *9451*; occasional, grasslands.

Laennecia coulteri (A. Gray) Nesom [*Conyza coulteri* A. Gray]. Summer annual. SC: *9649*; uncommon, sandy soil along Sonoita Creek. SR: *8338*; occasional, grasslands.

Laennecia sophiifolia (Kunth) Nesom [*Conyza sophiaefolia* Kunth]. Annual. SC: *8765*; uncommon, canyons. SR: *9657*; occasional, grasslands.

Lasianthaea podocephala (A. Gray) K. Becker [*Zexmenia podocephala* A. Gray]. Herbaceous perennial. SC: *8535*, *9583*; rare, below trees in canyons. SR: *9629*; rare, oak woodland adjacent to Parker Canyon.

Machaeranthera gracilis (Nutt.) Shinners [*Aplopappus gracilis* (Nutt.) A. Gray]. Annual. SC: *8666*; common, grasslands, uplands. SR: *8347*; common, grasslands.

Machaeranthera pinnatifida (Hook.) Shinners ssp. *pinnatifida* var. *pinnatifida* [*Aplopappus spinulosus* (Pursh) DC. var. *turbinellus* (Rydberg) Blake]. Herbaceous perennial. SR: *9301*; locally common, grasslands.

Machaeranthera tagetina Greene [*Aster tagetinus* (Greene) Blake]. Herbaceous perennial. SC: *8393*, *9586*; common, below mesquite. SR: *9572*; abundant, grasslands.

Machaeranthera tanacetifolia (Kunth) Nees [*Aster tanacetifolius* (Kunth) Nees]. Herbaceous perennial. SC: *9722*; uncommon, along Sonoita Creek. SR: *8343*, *8703*, *9600*, *9677*; common, roadsides, Parker Canyon, Santa Cruz floodplain.

Malacothrix clevelandii A. Gray. Cleveland yellow saucers; winter annual. SC: *9079*, *9121*; uncommon, canyons and rocky slopes. SR: *9242*; uncommon, mostly below oaks.

Malacothrix fendleri A. Gray. Desert dandelion; winter annual. SC: *9015*; common, mesquite grasslands. SR: *9097*, *9157*; common, grasslands.

Melampodium longicorne A. Gray. Summer annual. SC: *8385*; uncommon, canyons. SR: *8591*; rare, Parker Canyon.

Melampodium sericeum Lag. [*M. hispidum* Kunth]. Summer annual. SC: *8663*; uncommon, canyons. SR: *8309*, *8701*; common, Parker Canyon.

Packera neomexicana (A. Gray) W. A. Weber & A. Löve [*Senecio neomexicanus* A. Gray]. New Mexico groundsel; herbaceous perennial. SR: *9387*; rare, drainages.

Parthenice mollis A. Gray. Robust summer annual. SC: *8494*; rare, canyons.

Pectis filipes Harvey & A. Gray. Fetid marigold; summer annual. SC: *8471*; uncommon, uplands.

Pectis longipes A. Gray. Fetid marigold; herbaceous perennial. SC: *9228*; uncommon, mesquite grassland. SR: *8777*, *9375*; uncommon, grasslands.

Pectis prostrata Cav. Fetid marigold; summer annual. SC: *8531*; uncommon, grasslands. SR: *9618*; rare, Parker Canyon.

Porophyllum gracile Benth. Odora; herbaceous perennial. SC: *9364*; rare, uplands.

Porophyllum ruderale (Jacq.) Cass. ssp. *macrocephalum* (DC.) R.R. Johnson [*P. macrocephalum* DC.]. *Yerba del venado*; summer annual. SC: *8423*; uncommon, canyons.

Pseudognaphalium canescens (DC.) W. A. Weber ssp. *canescens* [*Gnaphalium wrightii* A. Gray]. Cudweed; herbaceous perennial. SC: *8766*; uncommon, canyons. SR: *8318*, *8699*; locally common, grasslands.

Pseudognaphalium leucocephalum (A. Gray) A. Anderb. [*Gnaphalium leucocephalum* A. Gray]. White cudweed; herbaceous perennial. SC: *8388*, *8755*; uncommon, canyon bottom. SR: *9691*; uncommon, Parker Canyon.

Pseudognaphalium pringlei (A. Gray) A. Anderb. [*Gnaphalium pringlei* A. Gray]. Cudweed; herbaceous perennial. SR: *9519*; occasional, grasslands.

Pseudognaphalium stramineum (Kunth) W. A. Weber [*Gnaphalium chilense* Spreng.]. Cudweed; annual. SC: *9233*; uncommon, canyons. SR: *8267*; occasional, Santa Cruz River bottom.

Psilactis asteroides A. Gray. Summer annual. SR: *8241*; abundant, low areas, roadsides, washes.

Pyrrhopappus pauciflorus (D. Don) DC. [*P. multicaulis* DC.]. False dandelion; herbaceous perennial. SR: *8305*, *8328*, *9371*; uncommon, springs and Santa Cruz River bottom.

Rafinesquia californica Nutt. California chicory; winter annual. SC: *9362*; uncommon, rocky slopes.

Rafinesquia neomexicana A. Gray. Desert chicory; winter annual. SC: *9012*, *9016*; common, canyons, rocky slopes.

Sanvitalia abertii A. Gray. Summer annual. SC: *8485*; rare, canyons. SR: *8718*, *9625*; uncommon, Parker Canyon.

Senecio flaccidus Less. var. *flaccidus* [*S. longilobus* Benth.]. Threadleaf groundsel; shrub. SC: *9284*; occasional, canyons. SR: *8778*; occasional, grasslands.

Solidago velutina DC. [*S. sparsiflora* A. Gray]. Goldenrod; herbaceous perennial. SC: *9712*; rare, one patch found in canyon west of Fresno Canyon. SR: *8578*; uncommon, mostly oak woodlands.

**Sonchus asper* (L.) Hill. Sow thistle; annual. SC: *9151*; occasional, mostly in canyons. SR: *9156*, *9317*; occasional, Santa Cruz River bottom.

Stephanomeria exigua Nutt. Wire lettuce; annual. SC: *9471*; rare, canyons.

Stephanomeria pauciflora (Torr.) A. Nelson. Wire lettuce; herbaceous perennial. SC: *9366*; occasional, canyons and uplands. SR: *8723*, *9401*; occasional, grasslands.

Stephanomeria thurberi A. Gray. Wire lettuce; summer annual. SR: *9450*; occasional, grasslands.

Symphyotrichum divaricatum (Nutt.) Nesom [*Aster exilis* Ell.]. Annual. SC: *8469*; common in wetlands. SR: *8782*; occasional, springs, Santa Cruz River bottom.

Symphyotrichum falcatum (Lindley) Nesom var. *commutatum* (Torr. & A. Gray) Nesom [*Aster commutatus* (Torr. & A. Gray) A. Gray]. White prairie daisy; perennial herb. SR: *8571*; common, springs.

**Taraxacum officinale* G. H. Weber ex F. H. Wigg. Dandelion; annual. SC: *9475*; rare in wet ground along streams. SR: *9112*; uncommon, springs.

Thelesperma megapotamicum (Spreng.) Kuntze. Herbaceous perennial. SR: *9369*; common, grasslands.

Thymophylla pentachaeta (DC.) Small var. *hartwegii* (A. Gray) Strother [*Dyssodia pentachaeta* (DC.) B. L. Robinson]. Herbaceous perennial. SC: *9221*, *9272*; uncommon, uplands.

Tithonia thurberi A. Gray. Summer annual. SC: *8544*; uncommon, north-facing slopes.

Townsendia exscapa (Richardson) Porter. Herbaceous perennial. SR: *9257*; rare, grasslands.

Trixis californica Kellogg. Shrub. SC: *8364*; occasional, canyons and rocky slopes.

Uropappus lindleyi (DC.) Nutt. [*Microseris linearifolia* (DC.) Schultz-Bip.]. Silver puffs; winter annual. SC: *8867*, *8924*; occasional, uplands. SR: *9054*; occasional, grasslands, below oaks.

Verbesina encelioides (Cav.) Benth. & Hook. f. ssp. *exauriculata* (Robinson & Greenm.) J. R. Coleman. Crownbeard; summer annual. SC: *8691*; uncommon, weedy terrace adjacent to Sonoita Creek. SR: uncommon, Parker Canyon.

Viguiera cordifolia A. Gray. Golden eye; herbaceous perennial. SR: *8598*; locally common, Parker Canyon.

Viguiera dentata (Cav.) Spreng. var. *dentata*. Golden eye; herbaceous perennial. SC: *8672*; abundant in mesquite bosques adjacent to Sonoita Creek. SR: *8586*; abundant, oak woodlands.

Viguiera dentata (Cav.) Spreng. var. *lancifolia* Blake. SC: *8824*; occasional, rocky slopes.

Xanthium strumarium L. var. *canadense* (P. Mill.) Torr. & A. Gray [*X. saccharatum* Wallr.]. Cocklebur, *abrojo*; summer annual. SC: *8758*; abundant in moist ground along streams. SR: *8597*; common, low areas, washes, Santa Cruz River bottom.

Xanthocephalum gymnospermoides (A. Gray) Benth. & Hook. Summer annual. SR: *8262*; abundant, grasslands.

Zinnia acerosa (DC.) A. Gray [*Z. pumila* A. Gray]. Desert zinnia; low shrub. SC: *9326*; uncommon, uplands.

Zinnia grandiflora Nutt. Prairie zinnia; herbaceous perennial. SR: *9400*; occasional, grasslands.

Zinnia peruviana (L.) L. [*Z. multiflora* L.]. Summer annual. SR: *8720*; uncommon, Parker Canyon.

Berberidaceae

Berberis wilcoxii Kearney. Barberry; shrub. SC: *9216*; rare, north-facing slope in Fresno Canyon.

Bignoniaceae

Chilopsis linearis (Cav.) Sweet ssp. *arcuata* (Fosberg) Henrickson. Desert willow, *mimbre*; small tree. SC: *9468*; uncommon, along Sonoita Creek. SR: *9621*; abundant, Parker Canyon.

Tecoma stans (L.) Juss. ex Kunth var. *angustatum* Rehder. Trumpet flower, *lluvia de oro*, *palo de arco*, *gloria*; shrub. SC: *8821*; rare, rocky slopes.

Bixaceae

Amoreuxia palmatifida Moc. & Sessé ex DC. *Témaqui*, *saiya*; perennial herb. *E.A. Lewis 011*; common, grasslands and uplands. SR: *9526*; rare, grasslands.

Boraginaceae

Amsinckia menziesii (Lehm.) A. Nelson & J. F. Macbride var. *intermedia* (Fischer & C. A. Meyer) Ganders [*A. intermedia* Fischer & C. A. Meyer]. Fiddleneck; winter annual. SC: *9021*; rare, Coal Mine Canyon.

Cryptantha angustifolia (Torr.) Greene. Narrow-leaved popcorn flower; winter annual. SC: *9139A*; uncommon, rocky uplands.

Cryptantha barbigera (A. Gray) Greene. Bearded popcorn flower; winter annual. SC: *8902*, *8906*, *8925*, *9087*; abundant, canyons and uplands. SR: *9384*; rare, oak savannas.

Cryptantha micrantha (Torr.) I. M. Johnston var. *micrantha*. Purple-rooted popcorn flower; winter annual. SC: *9133*; uncommon, sandy floodplain of Sonoita Creek.

Cryptantha pterocarya (Torr.) Greene var. *cycloptera* (Greene) J. F. Macbride. Winter annual. SC: *8866*, *9119*; abundant, mostly on rocky slopes.

Cryptantha pusilla (Torr. & A. Gray) Greene. Popcorn flower; winter annual. SC: *8865*, *9069*, *9139B*; uncommon, canyons and rocky uplands. SR: *9155*; uncommon, grasslands.

Lithospermum cobrense Greene. Puccoon; herbaceous perennial. SR: *9482*, *9486*; common, grasslands.

Lithospermum incisum Lehm. Puccoon; herbaceous perennial. SR: *9302*; occasional, grasslands.

Pectocarya recurvata I. M. Johnston. Arch-nutted combbur; winter annual. SC: *8845*, *9132*; occasional, canyons, slopes. SR: *9153*; occasional, grasslands, disturbed areas.

Plagiobothrys arizonicus (A. Gray) Greene ex A. Gray. Blood weed, Arizona popcorn flower; winter annual. SC: *8855*, *9116*; common, grasslands and canyons. SR: *8945*; common, sacaton flats, grasslands.

Brassicaceae

Arabis perennans S. Watson. Rock cress; herbaceous perennial. SC: *8831*, *8858*; uncommon, rock walls.

**Capsella bursa-pastoris* (L.) Medik. Shepard's purse, *paniquesillo*; winter annual. SC: *9266*; rare, gallery forest along Sonoita Creek. SR: *9047*; uncommon, disturbed areas.

Descurainia pinnata (Walt.) Britton ssp. *halictorum* (Cockerell) Detling. Tansy mustard; winter annual. SC: *8848*; common, canyons and uplands. SR: *9058*; abundant, roadsides, grasslands.

Descurainia pinnata (Walt.) Britton ssp. *ochroleuca* (Wooton) Detling. Tansy mustard; winter annual. SR: *8939*; abundant, roadsides, grasslands.

**Descurainia sophia* (L.) Webb ex Prantl. Flixweed; winter annual. SC: *9131*; uncommon, along Sonoita Creek. SR: *9048*; common, roadsides, grasslands.

Draba cuneifolia Nutt. ex Torr. & A. Gray var. *integrifolia* S. Watson. Whitlow grass; winter annual. SC: *8826*, *8840*; common, canyons. SR: *8948*; uncommon, grasslands.

Dryopetalon runcinatum A. Gray. Winter annual. SC: *8873*, *9013*; rare, rock walls, Fresno and Coal Mine canyons.

**Lepidium campestre* (L.) Ait. f. Peppergrass; winter annual. SR: *9300*; rare, springs.

Lepidium lasiocarpum Nutt. var. *lasiocarpum*. Sand peppergrass; winter annual. SC: *8851*; common, grasslands and drainages. SR: *8935*; abundant, low areas, grasslands.

Lepidium thurberi Wooton. Peppergrass; spring-

summer annual. SC: *9491*; uncommon, canyons. SR: *9303*; locally abundant, Parker Canyon, grasslands.

Lepidium virginicum L. var. *medium* (Greene) C. L. Hitchcock [*L. medium* Greene]. Peppergrass; winter annual. SC: *8842*; common, rocky slopes.

Lesquerella gordonii (A. Gray) S. Watson var. *gordonii*. Bladder pod; winter annual. SC: *8878*; rare, canyons.

Pennellia micrantha (A. Gray) Nieuwl. [*Thelypodium micranthum* (A. Gray) S. Watson]. Annual or biennial. SC: *9510, 9645*; rare, north-facing slopes, Coal Mine Canyon.

Pennellia robinsonii Rollins. Annual or biennial. SR: *8256, 8307, 9567, 9597*; occasional, grasslands, springs.

Rorippa nasturtium-aquaticum (L.) Hayek. Watercress, *berro*; aquatic herbaceous perennial. SC: *9146*; occasional, in streams. SR: *9160*; occasional, springs, Santa Cruz River.

Schoenocrambe linearifolia (A. Gray) Rollins [*Sisymbrium linearifolium* (A. Gray) Payson]. Herbaceous perennial. SC: *8379, 8476*; common, rocky slopes. SR: *8721*; uncommon, grasslands.

Sibara virginica (L.) Rollins. Winter annual. SR: *9249*; uncommon, sacaton flats.

**Sisymbrium irio* L. London rocket; winter annual. SC: *9013*; common, particularly in overgrazed mesquite grasslands. SR: *9046*; occasional, disturbed areas.

Streptanthus carinatus C. Wright ex A. Gray ssp. *arizonicus* (S. Watson) Kruckeberg, Rodman & Worthington [*S. arizonicus* S. Watson]. Twist flower; winter annual. SC: *9075, 9090*; rare, desert grasslands.

Thlaspi montanum L. var. *fendleri* (A. Gray) P. Holmgren [*T. fendleri* A. Gray]. Wild candytuft; herbaceous perennial. SR: *8947*; uncommon, north-facing slope adjacent to Sharp Spring.

Thysanocarpus curvipes Hook. Lace pod; winter annual. SC: *8846*; occasional, rocky slopes.

Cactaceae

Coryphantha vivipara (Nutt.) Britton & Rose in N. L. Britton & A. Brown [*C. vivipara* var. *bisbeeana* (Orcutt) L.D. Benson]. Beehive cactus; small stem succulent. SC: uncommon, grasslands. SR: occasional, grasslands.

Cylindropuntia leptocaulis (DC.) F. M. Knuth in C. Backeberg & F. M. Knuth [*Opuntia leptocaulis* DC.]. Desert Christmas cactus, succulent. SC: rare, included based on a photo by R. Gagnon.

Cylindropuntia spinosior (Engelm.) F. M. Kunth in C. Backeberg & F. M. Kunth [*Opuntia spinosior* (Engelm.) Toumey]. Cane cholla, *cholla*; large succulent. SC: common, grasslands and rocky slopes. SR: occasional, grasslands, Parker Canyon.

Cylindropuntia versicolor (Engelm. ex J. M. Coulter) F. M. Knuth in C. Backeberg & F. M. Kunth [*Opuntia versicolor* Engelm. ex J.M. Coulter]. Staghorn cholla, *cholla, siviri*; large succulent. SC: rare, a single, sterile plant in a drainage on the north end of the park appears to be this species.

Echinocereus fendleri (Engelm.) Sencke ex J. N. Haage. Hedgehog cactus; small stem succulent. SC: occasional, grasslands and rocky slopes.

Echinocereus rigidissimus (Engelm.) Engelm. ex Haage. [*E. pectinatus* (Scheidw.) Engelm. var. *rigidissimus* (Englem.) Engelm. ex Rumpler]. Rainbow cactus; small stem succulent. SC: occasional, rocky slopes. SR: uncommon, grasslands.

Echinomastus intertextus (Engelm.) Britton & Rose]. Small stem succulent. SR: *8953*; locally common, grasslands.

Ferocactus wislizeni (Engelm.) Britton & Rose. Barrel cactus; large stem succulent. SC: occasional, grasslands.

Mammillaria grahamii Engelm. [*M. microcarpa* Engelm.]. Fishhook cactus; small stem succulent. SC: occasional, rocky slopes.

Mammillaria macdougalii Rose in L.H. Bailey]. Small, flat succulent. SC: occasional, rocky slopes, canyons.

Opuntia engelmannii Salm-Dyck ex Engelm. var *engelmannii*. Engelmann prickly pear, *nopal*; large succulent. SC: common, mostly in mesquite grasslands. SR: uncommon, grasslands, oak woodlands.

Opuntia macrorhiza Engelm. [*O. plumbea* Rose]. Prickly pear; small succulent. SR: occasional, grasslands.

Opuntia phaeacantha Engelm. Prickly pear, *nopal*; sprawling succulent. SC: occasional, grasslands. SR: uncommon, grasslands.

Opuntia santa-rita (Griffiths & Hare) Rose. Santa Rita prickly pear, *nopal*; large succulent. SC: abundant on rocky slopes.

Campanulaceae

Lobelia cardinalis L. Cardinal flower; perennial herb. SC: *8490*; uncommon, wet soil along streams.

Lobelia fenestralis Cav. Summer annual. SR: *8555*; uncommon, grasslands, sacaton flats.

Nemacladus glanduliferus Jepson var. *orientalis* McVaugh. Thread plant; winter annual. SC: *9070*, *9135*; locally common, rocky slopes, canyons.

Triodanis holzingeri McVaugh. Venus looking glass; annual. SC: *9359*; rare, canyons.

Triodanis perfoliata (L.) Nieuwl. Venus looking glass; annual. SC: *9203*, *9223*; occasional, canyons.

Capparaceae

Cleome lutea Hook. var. *jonesii* J.F. Macbride [*C. jonesii* J.F. Macbride]. Bee plant; robust summer annual. SC: *8688*; uncommon, sandy soils adjacent to Sonoita Creek.

Polanisia dodecandra (L.) DC. ssp. *trachysperma* (Torr. & A. Gray) Iltis [*P. trachysperma* Torr. & A. Gray]. Clammy weed; summer annual. SC: *8464*; occasional, along streams. SR: *8717*; common, Parker Canyon.

Caprifoliaceae

Sambucus mexicana K. Presl ex DC. Mexican elder, *tápiro*; small tree. SC: *8915*; common along Sonoita Creek. SR: *9440*; occasional, Santa Cruz River floodplain. Kartesz (1999) includes this taxon as a synonym of the widespread *S. nigra* L. ssp. *canadensis* (L.) R. Bolli. Mexican elder is a low-elevation, early spring-flowering species, while the variety of *S. nigra* [*S. caerulea* Raf.] found in Arizona occurs at much higher elevations and flowers in the summer and fall.

Caryophyllaceae

Cerastium texanum Britton. Mouse-ear chickweed; annual. SC: *9020*; rare, north-facing slopes, Fresno and Coal Mine canyons.

Drymaria molluginea (Lag.) Didr. [*D. sperguloides* A. Gray]. Drymary; summer annual. SC: *8472*; uncommon, rocky uplands.

Silene antirrhina L. Sleepy catchfly; winter annual. SC: *9027*; common, rocky slopes. SR: *9307*; uncommon, oak woodland adjacent to Parker Canyon.

Chenopodiaceae

Atriplex canescens (Pursh) Nutt. var. *canescens*. Saltbush, *orache*; shrub. SC: *8823*; uncommon, overgrazed ridgetops.

Atriplex elegans (Moq.) D. Dietr. var. *elegans*. Summer annual. SR: *9513*; occasional, grasslands, roadsides.

Atriplex wrightii S. Watson. Wright saltbush; summer annual. SR: *8271*, *9560*; abundant, Santa Cruz River floodplain, roadsides.

**Chenopodium ambrosioides* L. Goosefoot, *hipasote*; annual. SC: *8744*; uncommon, along Sonoita Creek.

Chenopodium berlandieri Moq. var. *sinuatum* (Murr) Wahl. Pitseed goosefoot; summer annual. SR: *8704*, *8732*, *9615*; occasional, Parker Canyon, grasslands.

Chenopodium fremontii S. Watson var. *fremontii*. Goosefoot; annual. SC: *8382*; occasional, canyons. SR: *9690*; uncommon, Parker Canyon.

Chenopodium neomexicanum Standley var. *neomexicanum*. Goosefoot; summer annual. SC: *8382*, *9548*, *9670*; common, canyons, uplands. SR: *9662*; uncommon, below oaks.

Chenopodium watsoni A. Nelson. Goosefoot; summer annual. SR: *8258*; occasional, low areas, grasslands.

Monolepis nuttalliana (J.A. Schultes) Greene. *Patata;* winter annual. SR: *8941*; locally abundant, grasslands.

**Salsola tragus* L. [*S. kali* L. var. *tenuifolia* Tausch]. Tumbleweed, Russian thistle; summer annual. SC: uncommon, disturbed sites. SR: *9564*; abundant, roadsides.

Convolvulaceae

Convolvulus equitans Benth. [*C. incanus* Vahl]. Hoary bindweed; herbaceous perennial vine. SC: *9585*; uncommon, mostly in canyons. SR: *8710*; occasional, grasslands.

Evolvulus alsinoides (L.) L. var. *angustifolia* Torr. Herbaceous perennial. SC: *9127*; rare, rocky slopes.

Evolvulus arizonicus A. Gray. Herbaceous perennial. SC: *8515*, *9493*; occasional, canyons, rocky slopes. SR: *8308*; occasional, grasslands.

Evolvulus sericeus Sw. var. *sericeus*. Herbaceous perennial. SC: *9509*; rare, canyons. SR: *9381*; occasional, grasslands, oak woodlands.

Ipomoea barbatisepala A. Gray. Morning glory; summer annual vine. SC: *8394*, *9582*; common, canyons.

Ipomoea capillacea (Kunth) G. Don [*I. muricata* Cav. *sensu* Kearney & Peebles (1960)]. Morning glory; herbaceous perennial. SR: *9520*; uncommon, grasslands.

Ipomoea costellata Torr. Morning glory; summer annual vine. SC: *8366*, *8513*; common, canyons and uplands. SR: *8323*, *9607*; occasional, grasslands, Parker Canyon.

Ipomoea cristulata Hallier f. [*I. coccinea* L. *sensu* Kearney and Peebles (1960)]. Star glory, *trompillo*; summer annual vine. SC: *8466*; common, canyons. SR: *8593*; common, Parker Canyon.

Ipomoea hederacea Jacq. Morning glory; summer annual vine. SC: *9678*; common, canyons. SR: *8595*, *9610*, *9727*; common, Parker Canyon.

Ipomoea longifolia Benth. Morning glory; long-stemmed perennial vine. SR: *9515*; common, oak savannas.

Ipomoea purpurea (L.) Roth [*I. hirsutula* Jacq. f.]. Tall morning glory; summer annual vine. SC: *8376*; occasional, canyons.

Ipomoea ternifolia Cav. var. *leptotoma* (Torr.) J.A. McDonald [*I. leptotoma* Torr.]. Morning glory; summer perennial vine. SC: *8365*; common, canyons.

Ipomoea thurberi A. Gray. Morning glory; summer perennial vine. SC: *8473*; rare, canyons.

Crassulaceae

Crassula connata (Ruiz & Pavón) Berger var. *connata* [*Tillaea erecta* Hook. & Arn.]. Pigmy weed; winter annual. SC: *8931*; uncommon, grasslands.

Sedum cockerellii Britton. Stonecrop; succulent perennial herb. SC: *9704*; rare, rock walls.

Cucurbitaceae

Apodanthera undulata A. Gray. *Melón loco, melón de coyote*; herbaceous perennial vine. SC: *9555*; occasional, canyons and grasslands. SR: *8561*; occasional, grasslands.

**Citrullus lanatus* (Thunb.) Matsum. & Nakai. Watermelon; annual. SR: *9737*; rare, Parker Canyon.

Cucurbita digitata A. Gray. Finger-leaved gourd, *calabacilla, chichicayota*, herbaceous perennial vine. SC: uncommon, washes. SR: uncommon, grasslands.

Cucurbita foetidissima Kunth. Buffalo gourd, *calabacilla*; herbaceous perennial vine. SR: *9456*; occasional, grasslands.

Echinopepon wrightii (A. Gray) S. Watson. Wild balsam apple; herbaceous annual vine. SC: *8383*; uncommon, canyons.

Cuscutaceae

Cuscuta erosa Yuncker. Dodder; parasitic vine. SC: *8504*, *8526*; uncommon, found on *Tragia nepetifolia*.

Ericaceae

Arctostaphylos pungens Kunth. Manzanita; shrub. SR: *9055*; rare, oak savanna. One collection from near the north (unfenced) park boundary.

Euphorbiaceae

Acalypha neomexicana Muell.-Arg. New Mexican copperleaf; summer annual. SC: *8389*; uncommon, canyons. SR: *8248*, *9590*; common, grasslands.

Acalypha phleoides Cav. [*A. lindheimeri* Muell.-Arg.]. Herbaceous perennial. SR: *8249*; occasional, washes.

Acalypha ostryifolia Riddell. Hornbeam three-seeded mercury; summer annual. SC: *8484*; uncommon, canyons and slopes. SR: *8245*; occasional, washes.

Argythamnia neomexicana Muell.-Arg. [*Ditaxis neomexicana* (Muell.-Arg.) Heller]. Herbaceous perennial. SC: *8458*, *8835*; uncommon, rocky slopes.

Chamaesyce albomarginata (Torr. & A. Gray) Small [*Euphorbia albomarginata* Torr. & Gray]. Spurge, *golondrina*; herbaceous perennial. SC: *8461*; occasional, grasslands. SR: *8243*; occasional, disturbed areas.

Chamaesyce arizonica (Engelm.) Arthur [*Euphorbia arizonica* Engelm.]. Spurge, *golondrina*, herbaceous perennial. SC: *8377*, *8412*; occasional, rocky slopes.

Chamaesyce capitellata (Engelm.) Millsp. [*Euphorbia capitellata* Engelm.]. Spurge, *golondrina*; herbaceous perennial. SR: *8340*, *8565*; occasional, grasslands.

Chamaesyce dioica (Kunth) Millsp. [*Euphorbia indivisa* (Engelm.) Tidestrom]. Spurge, *golondrina*; summer annual. SC: *8463*; common, watercourses. SR: *8332*; occasional, washes.

Chamaesyce florida (Engelm.) Millsp. [*Euphorbia florida* Englem.]. *Golondrina*; summer annual. SC: *8470*; uncommon, grasslands and uplands.

Chamaesyce hirta (L.) Millsp. [*Euphorbia hirta* L.]. Spurge, *golondrina*; summer annual. SC: *8349*; occasional, canyons. SR: *8587*; occasional, washes.

Chamaesyce hyssopifolia (L.) Small [*Euphorbia hyssopifolia* L.]. *Golondrina*, summer annual. SC: *8387*; uncommon, canyons. SR: *8251*; occasional, washes, grasslands, roadsides.

Chamaesyce melanadenia (Torr.) Millsp. [*Euphorbia melanadenia* Torr.]. Spurge, *golondrina*; herbaceous perennial. SC: *8832, 9415*; occasional, rock walls.

Chamaesyce micromera (Boiss. ex Engelm.) Wooton & Standley [*Euphorbia micromera* Boiss.]. Spurge, *golondrina*; summer annual. SC: *8661*; uncommon, drainages.

Chamaesyce pediculifera (Engelm.) Rose & Standley var. *pediculifera* [*Euphorbia pediculifera* Engelm.]. Spurge, *golondrina*; herbaceous perennial. SC: *8359*; occasional, rocky slopes.

Chamaesyce revoluta (Engelm.) Small [*Euphorbia revoluta* Engelm.]. *Golondrina*; summer annual. SC: 8521; rare, rocky slopes. SR: 8716; rare, Parker Canyon.

Chamaesyce serpyllifolia (Pers.) Small [*Euphorbia serpyllifolia* Pers.]. Spurge, *golondrina*; summer annual. SR: *8253, 8695*; occasional, grasslands.

Chamaesyce setiloba (Engelm. ex Torr.) Millsp. ex Parish [*Euphorbia setiloba* Engelm.]. Spurge, *golondrina*; summer annual. SC: *8670*; rare, along Sonoita Creek.

Chamaesyce stictospora (Engelm.) Small [*Euphorbia stictospora* Engelm.]. Spurge, *golondrina*, summer annnal. SR: *8321, 8600*; occasional, grasslands.

Chamaesyce vermiculata (Raf.) House [*Euphorbia vermiculata* Raf.]. Spurge, *golondrina*; summer annual. SR: *8304*; occasional, springs.

Cnidoscolus angustidens Torr. *Mala mujer, ortiguilla*; herbaceous perennial. SC: *8456*; common, rocky slopes.

Croton pottsii (Klotzsch) Muell.-Arg. var. *pottsii* [*C. corymbulosus* Engelm.]. Leatherweed; herbaceous perennial. SC: *9542*; occasional, rocky slopes. SR: *8601*; occasional, grasslands.

Croton texensis (Klotzsch) Muell.-Arg. var. *texensis*. Dove weed, *yerba de la tórtola*, summer annual. SC: *8668, 8692*; uncommon, sandy soils along Sonoita Creek. SR: *8793*; uncommon, Santa Cruz River bottom.

Euphorbia bilobata Engelm. Summer annual. SR: *9613, 9718*; uncommon, Parker Canyon.

Euphorbia chamaesula Boiss. Herbaceous perennial. SR: *8281, 8333, 9312*; occasional, grasslands, roadsides.

Euphorbia cuphosperma (Engelm.) Boiss. [*E. dentata* Michx. var. *cuphosperma* (Engelm.) Fern.]. Painted spurge; summer annual. SC: *8240*; abundant, grasslands.

Euphorbia exstipulata Engelm. Spurge; summer annual. SC: *8459*; uncommon, mesquite grasslands. SR: *8244*; occasional, washes.

Euphorbia heterophylla L. Painted spurge; summer annual. SC: *8350*; uncommon, canyons and uplands. SR: *8311*; occasional, grasslands, springs.

Euphorbia radians Benth. Painted spurge; herbaceous perennial. SR: *9109*; common, grasslands.

Jatropha macrorhiza Benth. var. *septemfida* Engelm. Herbaceous perennial. SC: 9472; uncommon, canyons and uplands.

Manihot angustiloba (Torr.) Muell.-Arg. Herbaceous perennial. SC: *9541*; rare, canyons.

Phyllanthus polygonoides Nutt. ex Spreng. Herbaceous perennial. SC: *8488*; rare, Fresno Canyon.

Tragia laciniata (Torr.) Muell.-Arg. Nose burn; herbaceous perennial. SR: *8319*; occasional, mostly on north-facing slopes.

Tragia nepetifolia Cav. var. *dissecta* Muell.-Arg. Nose burn; herbaceous perennial. SC: *8358, 8500*; occasional, rocky slopes.

Fabaceae

Acacia angustissima (P. Mill.) Kuntze. White ball acacia; shrub. SC: *8418*; occasional, ridge crests. SR: *8698, 9478*; occasional, grasslands. Plants appearing to belong to different varieties may occur mixed in the same populations.

Acacia greggii A. Gray. Catclaw, *uña de gato*; large shrub. SC: *9358*; occasional, canyons.

Acacia millefolia S. Watson. Large shrub. SC: *8503, 9492*; rare, rocky slopes.

Amorpha fruticosa L. False indigo; large shrub. SC: *9286*; rare, one patch found in Fresno Canyon.

Astragalus allochrous A. Gray var. *allochrous*. Halfmoon loco; winter annual. SC: *9130*; uncommon, along Sonoita Creek.

Astragalus arizonicus A. Gray. Locoweed; herbaceous perennial. SC: *9129*, *9219*; common, uplands.

Astragalus humistratus A. Gray var. *sonorae* (A. Gray) Jones. Locoweed; herbaceous perennial. SR: *9258*; occasional, grasslands.

Astragalus nothoxys A. Gray. Locoweed; herbaceous perennial. SC: *9237*; uncommon, canyons and uplands. SR: *9306*; common, grasslands.

Astragalus nuttallianus DC. var. *trichocarpus* Torr. & A. Gray. Locoweed; winter annual. SC: *8904*; abundant, uplands. SR: *9093*; abundant, grasslands.

**Caesalpinia gilliesii* (Hook.) Wallich ex D. Dietr. Bird-of-paradise; shrub. SC: *9473*; rare, gallery forest along Sonoita Creek.

Calliandra eriophylla Benth. var. *eriophylla*. Fairy duster; low shrub. SC: *9327*; occasional, uplands.

Calliandra humilis Benth. var. *reticulata* (A. Gray) L. Benson [*C. reticulata* A. Gray]. False mesquite; herbaceous perennial. SR: *8559*; occasional, grasslands.

Chamaecrista nictitans (L.) Moench ssp. *nictitans* var. *leptadenia* (Greenman) Gandhi & Hatch [*Cassia leptadenia* Greenman]. *Yerba del piojo*; summer annual. SC: *8403*; occasional, grasslands and uplands. SR: *8257*; occasional, grasslands.

Cologania angustifolia Kunth [*C. longifolia* A. Gray]. Herbaceous perennial. SC: *9682*; rare, Fresno Canyon. SR: *E.A. Lewis* 004; uncommon, Parker Canyon.

Coursetia caribaea (Jacq.) Lavin var. *caribaea* [*Cracca edwardsii* A. Gray]. Herbaceous perennial. SC: *9504*; rare, oak savannas on north-facing slopes.

Crotalaria pumila Ortega. Rattle box; summer annual. SC: *8457*; occasional, canyons and uplands. SR: *8733*; occasional, mostly in Parker Canyon.

Dalea albiflora A. Gray. Herbaceous perennial. SC: *8808*; uncommon, canyons. SR: *8507*, *8579*; uncommon, grasslands.

Dalea candida Michx. ex Willd. var. *oligophylla* (Torr.) Shinners [*Petalostemon candidum* (Willd.) Michx. var. *oligophyllum* (Torr.) Herrmann]. White prairie clover; herbaceous perennial. SR: *9390*; occasional, grasslands.

Dalea formosa Torr. Feather plume, shrub. SC: *8674*, *9068*; locally common, uplands.

Dalea grayi (Vail) L.O. Williams. Herbaceous perennial. SR: *8506*; uncommon, grasslands.

Dalea lachnostachys A. Gray. Herbaceous perennial. SC: *9322*; uncommon, rocky uplands. SR: *8722*; uncommon, grasslands.

Dalea leporina (Ait.) Bullock. Foxtail dalea; summer annual. SR: *8620*; uncommon, grasslands.

Dalea nana Torr. ex A. Gray var. *carnescens* Kearney & Peebles. Herbaceous perennial. SC: *8524*, *9287*; occasional, rocky uplands. SR: *8549C*; occasional, grasslands.

Dalea neomexicana (A. Gray) A. Gray var. *neomexicana*. Herbaceous perennial. SC: *8682*, *9273*; uncommon, rocky uplands.

Dalea pogonathera A. Gray var. *pogonathera*. *Yerba del corazón*; herbaceous perennial. SC: *8512*; occasional, uplands.

Dalea pringlei A. Gray. Herbaceous perennial. SC: *8752*, *9222*, *9288*; occasional, canyon, rocky slopes.

Dalea pulchra H. S. Gentry. Indigo bush, shrub. SC: *8839*, *9126*; occasional, canyons, rocky slopes.

Dalea versicolor Zucc. ssp. *versicolor* var. *sessilis* (A. Gray) Barneby. Indigo bush; shrub. SR: *9305*, rare, oak woodland adjacent to Parker Canyon.

Desmanthus cooleyi (Eaton) Trel. Herbaceous perennial. SC: *9511*; rare, mesquite grasslands. SR: *9529*, *E.A. Lewis 002*; common, grasslands and roadsides.

Desmodium batocaulon A. Gray. Tick clover, herbaceous perennial. SC: *8489*; rare, canyons.

Desmodium neomexicanum A. Gray. Tick clover; summer annual. SC: *8541*; rare, canyons. SR: *9614*; uncommon, Parker Canyon.

Desmodium procumbens (P. Mill.) Hitchc. var. *exiguum* (A. Gray) Schub. Tick clover, summer annual. SC: *8681*, *8687*; rare, canyons.

Desmodium psilocarpum A. Gray. Tick clover, robust herbaceous perennial. SC: *8436*, *8443*, *9553*, *9701*; common, canyons and rocky slopes.

Desmodium rosei Schub. Tick clover; summer annual. SR: *9617*; uncommon, Parker Canyon.

Erythrina flabelliformis Kearney. Southwestern

coralbean, *chilicote, pionilla*; shrub. SC: *9411*; common, rocky slopes.

Eysenhardtia orthocarpa (A. Gray) S. Watson [*E. polystachya* (Ortega) Sarg. *sensu* Kearney & Peebles (1960)]. Kidneywood, *palo dulce*; large shrub. SC: *8431, 9412*; common, rocky slopes.

Galactia wrightii A. Gray var. *mollissima* Kearney & Peebles. Herbaceous perennial vine. SC: *8373*; occasional, canyons. SR: *9459*; rare, grasslands.

Indigofera sphaerocarpa A. Gray. Indigo, shrub. SC: rare, north-facing slope, Coal Mine Canyon.

**Lotus corniculatus* L. Birdsfoot trefoil; herbaceous perennial. SR: *8275B*; common, springs, Santa Cruz River bottom.

Lotus greenei Ottley ex Kearney & Peebles. Deer vetch. *9022*. Herbaceous perennial; uncommon, oak savannas. SR: *8949, 9479*; common, grasslands.

Lotus humistratus Greene. Winter annual. SC: *8877*; common, mesquite grasslands. SR: *8944*; abundant, grasslands.

Lupinus brevicaulis S. Watson. Short-stemmed lupine; winter annual. SC: *9080*; occasional, mostly along drainages. SR: *9105*; common, grasslands.

Lupinus concinnus J.G. Agardh. ssp. *orcuttii* (S. Watson) D. Dunn. Elegant lupine; winter annual. SC: *8930, 9063*; occasional, mostly along drainages. SR: *9107*; occasional, Parker Canyon.

Lupinus sparsiflora Benth. ssp. *mohavensis* Dziekanowski & D. Dunn. Lupine; winter annual. SC: *9008*; locally abundant, slopes.

Macroptilium gibbosifolium (Ortega) Delgado [*Phaseolus heterophyllus* Willd.]. Herbaceous perennial vine. SC: *8479*; uncommon, canyons. SR: *9517, 9569, 9659*; common, grasslands.

Marina calycosa (A. Gray) Barneby [*Dalea calycosa* A. Gray]. Annual. SC: *8679, 9274*; uncommon, uplands. SR: *9382*; uncommon, oak savannas.

**Medicago lupulina* L. Black medic; annual. SR: *9313, 9386*; common, springs, Santa Cruz River bottom.

**Medicago sativa* L. Alfalfa; herbaceous perennial. SR: *9370*; uncommon, roadsides.

**Melilotus indicus* (L.) All. Annual yellow sweet clover, *alfalfilla*; annual. SC: *9265*; occasional along Sonoita Creek. SR: *9298*; occasional, Santa Cruz River floodplain.

**Melilotus officinalis* (L.) Lam. Sweet clover; tall annual. SR *8790, 9426*; both white and yellow-flowered forms abundant, Santa Cruz River bottom.

Mimosa aculeaticarpa Ortega var. *biuncifera* (Benth.) Barneby [*M. biuncifera* Benth.]. Wait-a-minute, cat's claw; shrub. SC: *9470*; common, rocky slopes, canyons. SR: locally abundant, grasslands.

Mimosa dysocarpa Benth. Shrub. SC: *9353*; common, rocky slopes. SR: *8337*; occasional, grasslands.

Nissolia schottii (Torr.) A. Gray. Herbaceous perennial vine. SC: *8409*; uncommon, north-facing slopes.

Phaseolus acutifolius A. Gray var. *acutifolius*. Tepary bean; summer annual. SC: *9639*; uncommon, washes. SR: *9616*; uncommon, Parker Canyon.

Prosopis velutina Wooton [*P. juliflora* (Swartz) DC. var. *velutina* (Wooton) Sarg.]. Velvet mesquite, *mezquite*; small tree. SC: *9587*; common, washes, ridgetops, gentle slopes. SR: uncommon, grasslands.

Psoralidium tenuiflorum (Pursh) Rydberg [*Psoralea tenuiflora* Pursh]. Scurf pea; herbaceous perennial. SC: *9281*; rare, canyons. SR: *9396*; uncommon, oak woodland adjacent to Parker Canyon.

Rhynchosia minima (L.) DC. Rosary bean; herbaceous perennial vine. SC: *9706, 9733*; rare, rocky slopes, canyons.

Rhynchosia senna Gillies ex Hook. var. *texana* (Torr. & A. Gray) M.C. Johnston [*R. texana* Torr. & A. Gray]. Rosary bean; herbaceous perennial vine. SC: uncommon, north-facing slopes, canyons. SR: *8558, 9580*; occasional, grasslands.

Senna bauhinioides (A. Gray) Irwin & Barneby [*Cassia bauhinioides* A. Gray]. Herbaceous perennial. SC: *9325*; uncommon, uplands

Senna hirsuta (L.) Irwin & Barneby var. *glaberrima* (M.E. Jones) Irwin & Barneby [*Cassia leptocarpa* Benth.]. Robust herbaceous perennial. SC: *8381, 8465*; uncommon, canyon bottom. SR: *8556*; uncommon, grasslands.

Sphinctospermum constrictum (S. Watson) Rose.

Summer annual. SC: *8460*; rare, mesquite grasslands.

Tephrosia tenella A. Gray. Summer annual. SC: *8542*; uncommon, rocky slopes. SR: *8584*; uncommon, Parker Canyon.

Tephrosia vicioides Schlecht. Herbaeous perennial. SC: *8483*; rare, found on one ash outcrop, where it was locally abundant.

**Trifolium fragiferum* L. Clover; herbaceous perennial. SR: *9437*; uncommon, Santa Cruz River bottom.

Trifolium mucronatum Willd. ex Spreng. ssp. *lacerum* (Greene) J. Gillett [*T. lacerum* Greene]. Clover; herbaceous perennial. SR: *9523*; rare, wet ground.

**Trifolium pratense* L. Red clover, herbaceous perennial. SR: *9489*; uncommon, Santa Cruz River bottom.

Vicia ludoviciana Nutt. ssp. *ludoviciana*. Vetch, winter annual vine. SC: *8874*; common, washes.

Zornia gemella Vogel [*Z. diphylla* (L.) Pers. *sensu* Kearney & Peebles (1960)]. Herbaceous perennial. SR: *9571*; uncommon, grasslands.

Fagaceae

Quercus arizonica Sarg. Arizona white oak, *encino blanco*; tree. SR: *9452, 9457, 9663, 9738*; common in woodland adjacent to Parker Canyon.

Quercus emoryi Torr. Emory oak, *bellota*; tree. SC: *8533*; uncommon, canyons, north-facing slopes. SR: *9516*; common, oak savannas and oak woodlands.

Quercus grisea Liebm. Gray oak; tree. SR: *8344, 8346*; uncommon, a few trees just east of the Santa Cruz River appear to be this species.

Quercus oblongifolia Torr. Mexican blue oak, *encino azul*, tree. SC: *8775*; occasional, north-facing slopes, canyons.

Fouquieriaceae

Fouquieria splendens Engelm. Coach whip, *ocotillo*; shrub. SC: uncommon, rocky slopes.

Fumariaceae

Corydalis curvisiliqua Engelm. ssp. *occidentalis* (Engelm. ex A. Gray) W.A. Weber [*C. aurea* Willd. ssp. *occidentalis* (Englem. ex A. Gray) G.B. Ownbey]. Golden corydalis; winter annual. SC: *8869*; common, rocky slopes, canyons. SR: *8951*; occasional, Parker Canyon.

Garryaceae

Garrya wrightii Torr. Silk tassel; large shrub. SC: *9545*; uncommon, canyons.

Gentianaceae

Centaurium calycosum (Buckley) Fernald. Buckley's centaury, annual. SC: *9212*; uncommon along streams.

Centaurium nudicaule (Engelm.) B. L. Robinson. Annual. SC: *9230, 9295*; uncommon along streams.

Geraniaceae

**Erodium cicutarium* (L.) L'Her. ex Ait. ssp. *cicutarium*. Filaree, *alfilaria, afilerillo*; winter annual. SC: *9134*; occasional, mostly in mesquite grasslands. SR: *9050*; uncommon, disturbed areas.

Erodium texanum A. Gray. Heron bill; winter annual. SC: *9072*; uncommon, canyons and mesquite grasslands.

Grossulariaceae

Ribes aureum Pursh var. *aureum*. Golden current, shrub. SR: *9159*; rare, Sharp Spring, Santa Cruz River bottom.

Haloragaceae

Myriophyllum cf. *sibiricum* Komarov [*M. exalbescens* Fern.]. Water milfoil; submerged aquatic perennial. SR: *9247*; rare, Santa Cruz River bottom; not found in flower.

Hydrangeaceae

Fendlera wrightii (A. Gray) Heller [*F. rupicola* A. Gray var. *wrightii* A. Gray]. Large shrub. SC: *8407, 8836*; uncommon, north-facing slopes, canyons.

Philadelphus microphyllus A. Gray. Mock orange, shrub. SC: *9218, 9357*; rare, north-facing slope in Fresno Canyon. An atypically low-elevation record for this species.

Hydrophyllaceae

Eucrypta micrantha (Torr.) Heller. Winter annual. SC: *8829, 8850, 8853*; common, canyons, rocky slopes.

Nama hispidum A. Gray. Sand bells, winter annual. SC: *8913*; occasional, sandy soils adjacent to streams. SR: *9304*; occasional, Parker Canyon.

Phacelia affinis A. Gray. Purple bell phacelia; winter annual. SC: *9062, 9207, 9268*; common, mostly below mesquites.

Phacelia arizonica A.Gray.Winter annual.SC:*8856*; common, below mesquites, other heavily grazed areas.SR:*8943*;abundant,grasslands.
Phacelia bombycina Wooton & Standley.Winter annual. SC: *8905*, *9206*; occasional, rocky slopes.
Phacelia caerulea Greene.Winter annual.SC:*8911*; occasional,grasslands,canyons.
Phacelia distans Benth. Wild heliotrope; winter annual. SC: *9011*; locally abundant, rocky slopes.
Phacelia sonoitensis S.P. McLaughlin ined. Winter annual.SC:*9088*,*9123*,*9206*,*9226*;uncommon,talus slopes.

Hypericaceae

Hypericum scouleri Hook. ssp. *scouleri* [*H. formosum* Kunth].Herbaceous perennial.SR: *9577*;rare,springs.

Juglandaceae

Juglans major (Torr.) Heller. Arizona walnut, *nogal*;large tree.SC:*9416*;occasional,along Sonoita Creek and in the larger canyons.SR: *9454*;uncommon,Parker Canyon.

Krameriaceae

Krameria erecta Willd.ex J.A.Schultes [*K.parvifolia* Benth.]. Ratany, *tamichi*; low hemiparasitic shrub. SC: *9227*; occasional, rocky slopes. SR: *9380*;uncommon,oak savannas.
Krameria lanceolata Torr. Ratany; hemiparasitic herbaceous perennial.SR:*9393*;uncommon, grasslands.

Lamiaceae

Hedeoma dentata Torr.Mock pennyroyal;herbaceous perennial.SC:*8511*;uncommon,canyons. SR: *8727*; uncommon, oak woodland adjacent to Parker Canyon.
Hedeoma oblongifolia (A.Gray) Heller.Mock pennyroyal; herbaceous perennial. SC: *9584*; uncommon,canyons.
**Lamium amplexicaule* L. Dead nettle; winter annual. SC: *8910*; uncommon, mostly along Sonoita Creek.
**Marrubium vulgare* L. Common horehound, *marrubio*; herbaceous perennial. SR: *8326*; occasional,grasslands,roadsides;said to persist around abandoned homesteads.
Monarda citriodora Cerv.ex Lag.ssp.*austromontana* (Epling) Scora [*M. austromontana* Epling]. Bee balm, horsemint, *orégano*; herbaceous perennial. SR: *8238*; occasional, grasslands.
Prunella vulgaris L. ssp. *lanceolatus* (W. Bart.) Hultén. Self-heal; herbaceous perennial. SR: *9522*;rare,wet ground.
Salvia parryi A. Gray. Sage; low shrub. SC: *8683*, *9270*;uncommon,canyons.
Salvia subincisa Benth.Summer annual.SC:*8398*, *8451*; occasional, canyons and uplands. SR: *8250*;occasional,grassland.
Stachys coccinea Ortega. Texas betony; herbaceous perennial. SC: *8872*; locally common in canyons.
Trichostema arizonicum A. Gray. Blue curls; herbaceous perennial. SC: *8680*, *9546*; rare, canyons.

Linaceae

Linum puberulum (Engelm.) Heller. Plains flax; annual.SC:*9140*,*9278*;uncommon,uplands. SR:*8317*;uncommon,grasslands.

Loasaceae

Mentzelia albicaulis (Douglas ex Hook.) Douglas ex Torr.& A.Gray.Small flowered blazing star; winter annual.SC:*8847*,*8857*;occasional,rocky slopes. SR: *9098*; occasional, Parker Canyon.
Mentzelia isolata H.S.Gentry [*M.asperula* Wooton & Standley *sensu* Kearney and Peebles (1960)].Blazing star;summer annual.SC:*8368*, *8404*; occasional, rocky slopes.
Mentzelia multiflora (Nutt.) A. Gray. Adonis blazing star, *yerba pegajosa*; biennial or herbaceous perennial. SC: *8690*; occasional, sandy soils adjacent to Sonoita Creek. SR: *9373*; occasional, grasslands, roadsides.

Lythraceae

Lythrum californicum Torr. & A. Gray. Loosestrife, *yerba del cancer*; herbaceous perennial. SR: *8271*;common,springs.
Rotala ramosior (L.) Koehne. Toothe cup; summer annual.SC:*9674*;rare,wet soil of canyon bottom.

Malpighiaceae

Aspicarpa hirtella Rich.Herbaceous perennial.SR: *9594*;uncommon,oak savannas,grasslands.
Janusia gracilis A. Gray. Twining shrub. SC: *8516*; rare,ridgetops.

Malvaceae

Abutilon incanum (Link) Sweet. Indian mallow,

pelotazo; small shrub. SC: *8844*; uncommon, rocky slopes.

Abutilon mollicomum (Willd.) Sweet [*A. sonorae* A. Gray]. Tall herbaceous perennial. SC: *8447*; uncommon, canyons.

Abutilon parvulum A. Gray. Small-leaved abutilon; herbaceous perennial. SC: *9556*; rare, canyons.

Anoda abutiloides A. Gray. Tall herbaceous perennial. SC: *8386, 8442, 8753*; occasional, rocky slopes and canyons.

Anoda cristata (L.) Schlecht. Spurred anoda, *quesito*; summer annual. SC: *8462, 8662*; occasional, mostly in canyons. SR: *8566*; occasional, grasslands.

Gossypium thurberi Todaro. Desert cotton, shrub. SC: *8414*; locally common, canyons, slopes, ridgetops.

Herissantia crispa (L.) Brizicky [*Gayoides crispum* (L.) Small]. Herbaceous perennial. SC: *8411, 8517*; uncommon, rocky slopes and ridgetops.

Hibiscus biceptus S. Watson. Rose mallow; herbaceous perennial. SC: *8424*; uncommon, rocky slopes.

**Malva parviflora* L. Cheese weed; winter annual. SR: *9051*; uncommon, disturbed areas.

Rhynchosida physocalyx (A. Gray) Fryxell [*Sida physocalyx* A. Gray]. Herbaceous perennial. SC: *8486*; uncommon, canyons. SR: *8589*; uncommon, Parker Canyon.

Sida abutifolia P. Mill. [*S. procumbens* Sw.]. Prostrate herbaceous perennial. SC: 8546; occasional, grasslands. SR: *8551*; occasional, grasslands.

Sida neomexicana A. Gray. Herbaceous perennial. SR: *8580*; occasional, grasslands.

Sida spinosa L. Prickly mallow; summer annual. SR: *8336, 8568*; occasional, grasslands.

Sphaeralcea angustifolia (Cav.) G. Don var. *cuspidata* (A. Gray) Kearney. Narrow-leaved globe mallow; herbaceous perennial. SR: *8552*; occasional, mostly below oaks.

Sphaeralcea fendleri A. Gray var. *fendleri*. Globe mallow; robust herbaceous perennial. SR: *9687*; uncommon, Santa Cruz River floodplain.

Sphaeralcea laxa Wooton & Standley. Caliche globe mallow; herbaceous perennial. SC: *8811*; occasional, rocky slopes.

Menispermaceae

Cocculus diversifolius DC. Snail seed, *correhuela*; woody vine. SC: *9418*; uncommon, canyons, rocky slopes.

Molluginaceae

**Mollugo verticillata* L. Indian chickweed; annual. SC: *8413*; uncommon, rocky slopes. SR: *8288*; common, grasslands.

Moraceae

**Morus alba* L. Mulberry, *mora*. Tree. SR: rare, a single plant persisting near ranch buildings.

Morus microphylla Buckley. Texas mulberry, *mora*; small tree. SC: *9141*; occasional, canyons and rocky slopes.

Nyctaginaceae

Allionia incarnata L. Trailing four o' clock, windmills; trailing herbaceous perennial. SC: *8455, 9410*; common, canyons, grasslands.

Boerhavia coccinea P. Mill. Red spiderling; herbaceous perennial. SC: *8363*; common, washes, grasslands. SR: *8301*; occasional, grasslands, disturbed areas.

Boerhavia erecta L. Summer annual. SC: *8397, 8510*; uncommon, canyons and uplands. SR: *8592*; occasional, Parker Canyon.

Boerhavia intermedia M.E. Jones. Five-winged ringstem; summer annual. SC: *8514*; occasional, mesquite grasslands.

Boerhavia megaptera Standley. Summer annual. SC: *8815*; rare, grasslands.

Boerhavia purpurascens A. Gray. Purple spiderling; summer annual. SC: 8522; occasional, rocky slopes. SR: *8715*; uncommon, Parker Canyon.

Boerhavia scandens L. [*Commicarpus scandens* (L.) Standley]. Herbaceous perennial. SC: *8354*; common, below trees and shrubs in canyons.

Boerhavia spicata Choisy. Summer annual. SC: *8519*; occasional, sandy soil of canyon bottom. SR: *8714, 9715*; uncommon, Parker Canyon.

Mirabilis coccinea (Torr.) Benth. & Hook. f. [*Oxybaphus coccineus* Torr.]. Four o'clock, herbaceous perennial. SC: *9354*; rare, Fresno Canyon. SR: *8728B*; *9379*; uncommon, grasslands.

Mirabilis linearis (Pursh) Heimerl [*Oxybaphus linearis* (Pursh) B. L. Robinson]. Herbaceous perennial. SR: *8581, 8709*; uncommon, grasslands.

Mirabilis longiflora L. var. *wrightiana* (A. Gray ex

Britton & Kearney) Kearney & Peebles. Sweet four o'clock, *maravilla*; herbaceous perennial. SC: *9505*; rare, north-facing slopes. SR: *8730*, *9620*; uncommon, oak savannas.

Oleaceae

Fraxinus velutina Torr. Velvet ash, *fresno*; tree. SC: *8399*; common along Sonoita Creek and in larger canyons. SR: *8735*; uncommon, Parker Canyon.

Menodora scabra A. Gray. Small shrub. SC: *8675*, *9138*, *9324*; locally common, canyons.

Onagraceae

Camissonia californica (Nutt. ex Torr. & A. Gray) Raven [*Oenothera leptocarpa* Greene]. Winter annual. SC: *9009*, *9122*; occasional, canyons and rocky slopes.

Camissonia chamaenerioides (A. Gray) Raven [*Oenothera chamaenerioides* A. Gray]. Winter annual. SC: *9065*; uncommon, canyons.

Camissonia claviformis (Torr. & Frémont) Raven ssp. *peeblesii* (Munz) Raven [*Oenothera clavaeformis* Torr. & Frémont var. *peeblesii* Munz]. Winter annual. SC: *9071*; rare, one population seen in canyon of Sonoita Creek.

Epilobium canum (Greene) Raven ssp. *latifolium* (Hook.) Raven [*Zauschneria latifolia* (Hook.) Greene var. *arizonica* (Davidson) Hilend]. Hummingbird trumpet; herbaceous perennial. SC: *8750*; occasional, canyon bottom.

Epilobium ciliatum Raf. [*E. adenocaulon* Hausskn.]. Willow weed; herbaceous perennial. SR: *8274*; common, springs.

Gaura hexandra Ortega ssp. *gracilis* (Wooton & Standley) Raven & Gregory [*G. gracilis* Wooton & Standley]. Herbaceous perennial. SC: *8740*; occasional, canyons. SR: *8260*, *9481*; common, low areas.

Gaura mollis James [*G. parviflora* Douglas ex Lehm.]. Lizard tail, velvet leaf gaura; tall herbaceous perennial. SC: *8654*; occasional, mostly along Sonoita Creek. SR: *8263*; common, Sharp Spring, low areas, roadsides.

Oenothera albicaulis Pursh. Evening primrose; winter annual. SR: *9239*, *9477*, *9514*; locally common, grasslands.

Oenothera cespitosa Nutt. ssp. *marginata* (Nutt. ex Hook. & Arn.) Munz. Evening primrose; herbaceous perennial. SC: *9117*; rare, canyons. SR: *9091*; occasional, grasslands.

Oenothera primiveris A. Gray ssp. *primiveris*. Yellow desert primrose; herbaceous perennial. SC: *8834*, *8918*; common, grasslands. SR: *8940*; common, south-facing slopes.

Oenothera pubescens Willd. ex Spreng [*O. laciniata* Hill ssp. *pubescens*]. Evening primrose; annual. SR: *9378*, *9480*, *9518*; uncommon, grasslands.

Oenothera rosea L'Her. ex Ait. Sun drops; herbaceous perennial. SC: *8655*; uncommon, wet soil along edge of Sonoita Creek. SR: *8278*; common, springs.

Orobanchaceae

Orobanche cooperi (A. Gray) Heller ssp. *cooperi* [*O. ludoviciana* Nutt. var. *cooperi* (A. Gray) G. Beck]. Broom rape; holoparasitic herbaceous perennial. SC: *9269*, *9328*; occasional, grasslands, canyons.

Oxalidaceae

Oxalis albicans Kunth ssp. *albicans*. Wood sorrel, *socoyoli*; herbaceous perennial. SC: *8746*; uncommon, mostly along Sonoita Creek. SR: *8325*; occasional, grasslands.

Oxalis drummondii A. Gray [*O. amplifolia* (Trel.) Knuth *sensu* Kearney and Peebles (1960)]. Wood sorrel; herbaceous perennial. SC: *9540*, *9558*; uncommon, gallery forests along Sonoita Creek, canyons. SR: *9524*; uncommon, Parker Canyon.

Papaveraceae

Argemone mexicana L. Prickly poppy; annual. SC: *9290*; rare, along old railroad right-of-way along Sonoita Creek, possibly introduced.

Argemone pleiacantha Greene ssp. *pleiacantha*. Prickly poppy; annual. SC: *9285*; common along Sonoita Creek and in canyons. SR: *9425*; common, roadsides, grasslands.

Eschscholzia californica Cham. ssp. *mexicana* (Greene) C. Clark [*E. mexicana* Greene]. Mexican poppy, *amapola del campo*; winter annual. SC: 8833; common, uplands.

Passifloraceae

Passiflora mexicana Juss. Passion flower. Herbaceous perennial vine. SC: uncommon, gallery forest, canyons, not found in flower.

Pedaliaceae

Proboscidea parviflora (Wooton) Wooton & Standley ssp. *parviflora*. Devil's claw, *gatitio*;

summer annual. SC: *8374*; occasional, sandy soils adjacent to Sonoita Creek. SR: *8335*; common, grasslands.

Phytolaccaceae

Rivina humilis L. Pigeon berry, rouge plant, *coralito*; herbaceous perennial. SC: *8362*; common, canyons.

Plantaginaceae

**Plantago major* L. Common plantain; annual. SC: *8742, 9314*; rare, along Sonoita Creek.

Plantago patagonica Jacq. [*P. purshii* Roemer & Schultes]. Plantain; winter annual. SC: *8921*; abundant, uplands. SR: *9092*; abundant, grasslands.

Plantago virginica L. Pale-seeded plantain; winter annual. SC: *9225, 9231*; uncommon, mostly along drainages in wet soil. SR: *9244*; locally common, sacaton stands. Widespread in the United States and probably native in Arizona.

Platanaceae

Platanus wrightii S. Watson. Arizona sycamore, *aliso*; tree. SC: rare, present as a few saplings along Sonoita Creek.

Plumbaginaceae

Plumbago scandens L. Leadwort, *hierba de alacrán, pitillo*; herbaceous perennial. SC: *8408, 8748*; uncommon, canyons, rocky slopes.

Polemoniaceae

Eriastrum diffusum (A. Gray) Mason. Winter annual. SC: *9125, 9143*; uncommon, mesquite grasslands. SR: *9240*; occasional, grasslands.

Gilia flavocincta A. Nelson ssp. *australis* (A. & V. Grant) A. Day & V. Grant. Winter annual. SC: *8860, 9061*; common; gallery forests, canyons, and uplands. SR: *8942*; common, grasslands.

Gilia mexicana A. & V. Grant. Winter annual. SC: *9085*; uncommon, mostly ridgetops. SR: *9108*; common, grasslands.

Ipomopsis macombii (Torr. ex A. Gray) V. Grant [*Gilia macoumbii* Torr.]. Herbaceous perennial. SC: *8527*. Herbaceous; uncommon, canyons. SR: *8334*; uncommon, grasslands.

Linanthus aureus (Nutt.) Greene ssp. *aureus*. Winter annual. SC: *9089*; rare, mesquite grasslands.

Linanthus bigelovii (A. Gray) Greene. Winter annual. SC: *8861*; uncommon, canyons.

Phlox gracilis (Hook.) Greene [*Microsteris gracilis* (Hook.) Greene]. Winter annual. SC: *9214*; rare, Fresno Canyon.

Polygalaceae

Polygala alba Nutt. Milkwort; herbaceous perennial. SR: *8560, 8737*; uncommon, grasslands.

Polygala barbeyana Chod. [*P. longa* Blake]. Milkwort; herbaceous perennial. SC: *9405*; uncommon, canyons, rocky slopes. SR: *9521*; uncommon, grasslands.

Polygala obscura Benth. Milkwort; herbaceous perennial. SC: *8749, 9323*; uncommon, canyons, rocky slopes. SR: *9512*; uncommon, grasslands.

Polygonaceae

Eriogonum abertianum Torr. var. *abertianum*. Wild buckwheat; annual. SC: *8384*; common, all terrestrial habitats. SR: *8330, 8331*; occasional, grasslands.

Eriogonum polycladon Benth. Sorrel buckwheat; summer annual. SC: *8518*; occasional, sandy soils adjacent to Sonoita Creek, other disturbed areas. SR: *8697*; occasional, grasslands.

Eriogonum wrightii Torr. ex Benth. var. *wrightii*. Wright buckwheat; low shrub. SC: *9729*; occasional, canyons, rocky slopes. SR: *8779*; common, grasslands.

**Polygonum aviculare* L. Prostrate knotweed, *chilillo*; herbaceous perennial. SR: *8342*; locally abundant, tanks.

**Polygonum lapathifolium* L. Willow smartweed, *chilillo*; herbaceous perennial. SR: *8266*; locally abundant, cattle tanks, Santa Cruz River bottom.

Polygonum pensylvanica L. Pinkweed, *chilillo*; herbaceous perennial. SR: *8242*; locally abundant, low areas, cattle tanks.

Polygonum punctatum Ell. var. *confertiflorum* (Meisn.) Fassett. Water smartweed, *chilillo*; herbaceous perennial. SC: *8497, 8653*; occasional, stream edges.

**Rumex crispus* L. Curley dock; herbaceous perennial. SR: *8780, 9427*; occasional, springs.

Rumex hymenosepalus Torr. Wild rhubarb, *cañaigre*; herbaceous perennial. SC: uncommon, gallery forest along Sonoita Creek.

Rumex violescens Rech. f. Herbaceous perennial. SC: *9318*; uncommon, edge of Sonoita Creek.

Portulacaceae

Calandrinia ciliata (Ruiz & Pavón) DC. Red maids; winter annual. SC: *8854*; common, canyons, grasslands. SR: *8938*; common, low areas, roadsides.

Cistanthe parryi (A. Gray) Hershkovitz var. *arizonica* (J. T. Howell) Kartesz & Gandhi [*Calyptridium parryi* A. Gray]. Winter annual. SC: *8928*; uncommon, grasslands.

Portulaca suffrutescens Engelm. Purslane; herbaceous perennial. SC: *8420*; common, mesquite grasslands, ridgetops. SR: *8567*; uncommon, grasslands.

Portulaca umbraticola Kunth ssp. *coronata* (Small) Matthews & Ketron [*P. coronata* Small]. Purslane; summer annual. SC: *8371*; common, uplands. SR: *8286*, *8570*; uncommon, uplands.

Talinum aurantiacum Engelm. Flame flower; herbaceous perennial. SC: occasional, grasslands. SR: *8273*; occasional, grasslands.

Talinum paniculatum (Jacq.) Gaertn. Pink baby breath, *rama del sapo*; herbaceous perennial. SC: *8353*; common, canyons.

Primulaceae

**Anagallis arvensis* L. Pimpernel, *yerba de pajaro*; annual. SR: *9385*; uncommon, disturbed areas.

Androsace occidentalis Pursh. Rock jasmine; winter annual. SC: *8827*; common, canyons, uplands. SR: *8936*, *8950*; common, low areas, sacaton flats.

Samolus vagans Greene. Water pimpernel; herbaceous perennial. SC: *8492*; rare, wet soil along stream, Fresno Canyon.

Ranunculaceae

Anemone tuberosa Rydberg var. *tuberosa*. Desert windflower; herbaceous perennial. SC: *8825*; occasional, rocky slopes.

Clematis drummondii Torr. & A. Gray. Texas virgin bower, *barbas de chivito*; woody vine. SC: *9403*; uncommon, gallery forest along Sonoita Creek.

Delphinium scaposum Greene. Barestem larkspur; herbaceous perennial. SC: *9066*; locally common, uplands.

Delphinium wootonii Rydberg [*D. virescens* Nutt. ssp. *wootonii* (Rydberg) Ewan]. Larkspur; herbaceous perennial. SR: *9351*; rare, grasslands.

Myosurus cupulatus S. Watson. Mousetail; winter annual. SC: *8862*, *9010*, *9023*; abundant, wet soil of canyon bottom, north-facing slopes. SR: *8934*, *9056*; abundant, low areas, sacaton flats.

Myosurus minimus L. Mousetail; winter annual. SR: *9254*, *9350*; uncommon, springs.

Ranunculus hydrocharoides A. Gray var. *hydrocharoides*. Buttercup, herbaceous perennial. SR: *9259*; locally common, springs.

Ranunculus macranthus Scheele. Large buttercup; herbaceous perennial. SR: *9485*; uncommon, springs.

Thalictrum fendleri Engelm. ex A. Gray var. *fendleri*. Meadow rue; herbaceous perennial. SC: *8543*; rare, canyons, north-facing slopes.

Rhamnaceae

Ceanothus greggii A. Gray. Buckbrush; shrub. SC: *9544*; rare, canyons.

Condalia warnockii M. C. Johnston var. *kearneyana* M. C. Johnston [*Condalia mexicana* Schlecht. *sensu* Kearney & Peebles (1960)]. Mexican bluewood; shrub. SC: *8367*; occasional, rocky slopes.

Sageretia wrightii S. Watson. Shrub. SC: *8671*; locally common, canyons.

Zizyphus obtusifolia (Hook. ex Torr. & A. Gray) A. Gray var. *canescens* (A. Gray) M. C. Johnston [*Condalia lycioides* (A. Gray) Weberb.]. Gray thorn, *abrojo*, *bachata*; shrub. SC: *9494*; occasional, mostly along edge of gallery forest along Sonoita Creek.

Rosaceae

**Malus pumilla* P. Mill. Apple; tree. SR: *9484*, a few trees persisting at Sharp Spring near junction with Santa Cruz River floodplain.

Potentilla wheeleri S. Watson [*P. viscidula* Rydb.]. Cinquefoil; herbaceous perennial. SR: *9059*; uncommon, north-facing slopes in grasslands, usually found at much higher elevations in southeastern Arizona.

Purshia stansburiana (Torr.) Henrickson [*Cowania mexicana* D. Don var. *stansburiana* (Torr.) Jespon]. Cliffrose, *poño*; large shrub. SC: *9144*; occasional, uplands. SR: *8724*; uncommon, grasslands.

Rubiaceae

Bouvardia ternifolia (Cav.) Schlecht. [*B. glaberrima* Engelm.]. Shrub. SC: *8435*, *9361*; rare, north-facing slopes, ridgetops.

Diodia teres Walt. var. *angustata* A. Gray. Rough buttonweed, poor Joe; summer annual. SC: *8767*; rare, canyons. SR: *8719*; uncommon, grasslands.

Galium aparine L. Goosegrass bedstraw, cleavers; annual vine. SC: *9083*; common in canyons, below oaks.

Galium microphyllum A. Gray. Herbaceous perennial. SC: *9329, 9355*; uncommon, rock walls.

Galium proliferum A. Gray. Great Basin bedstraw; winter annual. SC: *9114, 9275*; uncommon, canyons.

Galium wrightii A. Gray. Herbaceous perennial. SC: *9702*; uncommon, rock walls.

Houstonia wrightii A. Gray. Herbaceous perennial. SR: *8316, 9527*; uncommon, north-facing slopes in grasslands.

Mitracarpus breviflorus A. Gray. Summer annual. SC: *8754, 9721*; uncommon, mostly canyon bottom. SR: *8547*; uncommon, grasslands.

Rutaceae

Thamnosma texana (A. Gray) Torr. Turpentine broom; herbaceous perennial. SC: *9067*; uncommon, uplands.

Salicaceae

Populus fremontii S. Watson. Fremont cottonwood, *álamo*; large tree. SC: common, gallery forest along Sonoita Creek. SR: common, springs, Santa Cruz River bottom.

Salix bonplandiana Kunth. Bonpland willow, *sauce, sauz*; tree. SC: *8651, 8665, 9264*; occasional, gallery forest along Sonoita Creek.

Salix exilifolia Dorn [*Salix taxifolia* Kunth]. Yewleaf willow, *taraiz*; small tree. SC: *8669, 9150*; rare, Sonoita Creek. SR: *9261*; uncommon, springs, Santa Cruz River bottom.

Salix gooddingii Ball. Goodding willow, *sauce, sauz*; tree. SC: *8876, 9148*; abundant, gallery forest along Sonoita Creek. SR: *9429*; common, springs, Santa Cruz River bottom.

Salix lasiolepis Benth. var. *lasiolepis*. Arroyo willow, *sauce*; large shrub. SC: *9064*; common, Sonoita Creek. SR: *8949, 9111, 9260, 9262*; common, springs, Santa Cruz River bottom.

Sapindaceae

Dodonaea viscosa (L.) Jacq. Hopbush, *jarilla, tarachiqui*; shrub. SC: *9734*; uncommon, canyons.

Sapindus saponaria L. var. *drummondii* (Hook. & Arn.) L. Benson. Western soapberry, *amolillo, cirioni, jaboncillo*; small tree. SC: *9498*; occasional, canyons, rocky slopes. SR: *8596*; uncommon, Parker Canyon.

Scrophulariaceae

Castilleja exserta (Heller) Chuang & Heckard ssp. *exserta* [*Orthocarpus purpurascens* Benth.]. Owl's clover; hemiparasitic winter annual. SC: *9208*; rare, mesquite grasslands.

Castilleja integra A. Gray. Indian paintbrush; hemiparasitic herbaceous perennial. SR: *9103, 9251*; occasional, grasslands.

Castilleja lanata A. Gray ssp. *lanata*. Indian paintbrush; hemiparasitic herbaceous perennial. SC: *8917, 9137*; uncommon, canyons.

Castilleja minor (A. Gray) A. Gray ssp. *minor*. Indian paintbrush; hemiparasitic annual. SC: *9030, 9213*; rare, canyon bottom.

Maurandella antirrhiniflora (Humb. & Bonpl. ex Willd.) Rothm. [*Maurandya antirrhiflora* Humb. & Bonpl.]. Herbaceous perennial vine. SC: *8677*; occasional, canyons, rock walls.

Mecardonia procumbens (P. Mill.) Small [*M. vandellioides* (Kunth) Pennell]. Herbaceous perennial. SC: *8445, 8468*; occasional, canyon bottom.

Mimulus floribundus Lindley. Monkey flower, *baisómari*; herbaceous perennial. SC: *9234*; rare, Coal Mine Canyon.

Mimulus guttatus DC. Monkey flower, *baisómari*; herbaceous perennial. SC: *8838*; common, riparian areas. SR: *9096*; common, Santa Cruz River bottom.

Mimulus rubellus A. Gray. Red-stemmed mimulus; winter annual. SC: *8828*; locally common, mostly in canyons. SR: *9053*; occasional, grasslands.

Nuttallanthus texanus (Scheele) D.A. Sutton [*Linaria texana* Scheele]. Texas toad flax; winter annual. SC: *8864, 8912*; common, rocky slopes. SR: *9094*; uncommon, grasslands.

Penstemon barbatus (Cav.) Roth ssp. *barbatus*. Scarlet bugler; herbaceous perennial. SC: *9407*; rare, Fresno Canyon. SR: *9453*; rare, oak woodlands adjacent to Parker Canyon.

Penstemon linarioides A. Gray ssp. *linarioides*. Herbaceous perennial. SR: *9383*; occasional, grasslands.

Penstemon parryi (A. Gray) A. Gray. Herbaceous perennial. SC: *9120*; occasional, rocky slopes, rock walls.

Penstemon stenophyllus (A. Gray) T. J. Howell. Beard-tongue; herbaceous perennial. SR: *9525, 9568*; uncommon, north-facing slopes in oak woodlands and grasslands.

Sairocarpus nuttallianus (Benth. ex A. DC.) D. A. Sutton [*Antirrhinum nuttallianum* Benth.]. Winter annual. SC: *9127*; rare, rocky slopes.

Schistophragma intermedia (A. Gray) Pennell. Summer annual. SC: *8480*; uncommon, canyons.

Stemodia durantifolia (L.) Sw. Herbaceous perennial. SC: *9404*; rare, rock walls, Fresno Canyon. SR: *8734*; rare, Parker Canyon.

**Verbascum virgatum* Stokes. Mullein; robust annual. SC: *9476*; uncommon, along Sonoita Creek. SR: *8306*; uncommon, springs.

**Veronica anagallis-aquatica* L. Water speedwell, herbaceous perennial. SC: *9145*; occasional, riparian areas.

Veronica peregrina L. ssp. *xalapensis* (Kunth) Pennell. Speedwell; winter annual. SC: *8859, 8932, 9115*; abundant, canyons and upland drainages. SR: *8952, 9346*; common, washes.

Simaroubaceae

**Ailanthus altissimus* (P. Mill.) Swingle. Tree of heaven, copal tree; tree. SC: one large colony in the gallery forest of Sonoita Creek. SR: *8272*; uncommon, small colony along road east of the Santa Cruz River.

Solanaceae

Calibrachoa parviflora (Juss.) D'Arcy [*Petunia parviflora* Juss.]. Wild petunia; annual. SC: *9149*; uncommon, wet soil along Sonoita Creek. SR: *9391*; uncommon, margins of cattle tanks.

Chamaesaracha coniodes (Moric. ex Dunal) Britton. Small ground cherry; herbaceous perennial. SC: *9296*; uncommon, grasslands. SR: *9441*; uncommon, roadsides.

Chamaesaracha coronopus (Dunal) A. Gray. False nightshade; herbaceous perennial. SR: *9367, 9402*; uncommon, roadsides.

Datura quercifolia Kunth. Jimsom weed, *toloache*; herbaceous perennial. SR: *8577*; uncommon, roadsides.

Datura wrightii Regel [*D. meteloides* DC.]. Sacred datura, *toloache*; herbaceous perennial. SC: *9539*; occasional, sandy soils adjacent to Sonoita Creek. SR: *8564*; occasional, roadsides.

Lycium berlandieri Dunal var. *parviflorum* (A. Gray) Terracc. Wolfberry; shrub. SC: *8814*; uncommon, uplands.

Lycium exsertum A. Gray. Wolfberry; shrub. SC: *8817*; uncommon, uplands.

Margaranthus solanaceus Schlecht. Netted globe berry; summer annual. SR: *8725*; uncommon, oak woodland adjacent to Parker Canyon.

**Nicotiana glauca* Graham. Tree tobacco, *cornetón, juan loco, palo loco*; robust herbaceous perennial. SC: *8693*; occasional along Sonoita Creek.

Nicotiana obtusifolia Martens & Galleotti var. *obtusifolia* [*N. trigonophylla* Dunal var. *trigonophylla*]. Desert tobacco, *tabaquillo*; herbaceous perennial. SC: *8684*; occasional, canyon walls.

Physalis acutifolia (Miers) Sandw. [*P. wrightii* A. Gray]. Wright ground cherry, *tomatito*; summer annual. SR: *8265, 8341*; occasional, grasslands, springs.

Physalis hederifolia A. Gray var. *hederifolia*. Ivy-leaved ground cherry, *tomatito*; herbaceous perennial. SR: *8588*; uncommon, Parker Canyon.

Physalis longifolia Nutt. *Tomatito*; herbaceous perennial. SR: *8299, 8300, 8706*; common, springs.

Physalis pubescens L. var. *integrifolia* (Dunal) Waterfall. Hairy ground cherry, *tomate, fresadilla*; summer annual. SC: *8390*; uncommon, canyons.

Solanum douglasii Dunal. Nightshade; herbaceous perennial. SC: *8491*; rare, Fresno Canyon.

Solanum elaeagnifolium Cav. Silverleaf nightshade, *trompillo*; herbaceous perennial. SC: *9363*; occasional, mesquite grasslands. SR: *9398*; occasional, disturbed areas.

Solanum rostratum Dunal. Buffalo bur; herbaceous perennial. SC: *9633*; uncommon, mostly along Sonoita Creek. SR: uncommon, roadsides.

Sterculiaceae

Ayenia filiformis S. Watson [*A. pusilla* L. *sensu* Kearney and Peebles (1960)]. Herbaceous perennial. SC: *8372*; occasional, rocky slopes.

Tamaricaceae

**Tamarix ramosissima* Ledeb. [*T. pentandra* Pall. *sensu* Kearney and Peebles (1960)]. Tamarisk,

pino salado; small tree. SR: *9348*; rare, Santa Cruz River bottom.

Ulmaceae

Celtis reticulata Torr. Hackberry, *palo blanco, cúmaro*; tree. SC: *9557*; common, gallery forests and canyons. SR: *8345*; uncommon, edge of Santa Cruz River floodplain.

Celtis pallida Torr. Desert hackberry, *garambullo*; shrub. SC: uncommon, rocky slopes.

Urticaceae

Parietaria hespera Hinton var. *hespera* [*P. floridana* Nutt. *sensu* Kearney and Peebles (1960)]. Pellitory, sprawling winter annual. SC: *8830*; occasional, rocky slopes.

Verbenaceae

Aloysia wrightii Heller ex Abrams. Wright lippia, *oreganillo*; shrub. SC: *8525*; common, rocky slopes.

Bouchea prismatica (L.) Kuntze. Summer annual. SR: *8259*; uncommon, low areas.

Glandularia bipinnatifida (Nutt.) Nutt. var. *bipinnatifida*. [*Verbena bipinnatifida* Nutt.]. Verbena; herbaceous perennial. SR: *8261*, *9101*; common, grasslands.

Phyla nodiflora (L.) Greene. Herbaceous perennial. SR: *9443*; one colony near ranch buildings, probably introduced.

Verbena carolina L. Herbaceous perennial. SC: *8739*; uncommon, canyons.

Verbena gracilis Desf. Herbaceous perennial. SR: *8255*; occasional, low areas.

Verbena neomexicana (A. Gray) Small var. *xylopoda* Perry. Hillside vervain; herbaceous perennial. SC: *8478, 8739*; occasional, mostly on shaded slopes.

Viscaceae

Phoradendron californicum Nutt. Desert mistletoe; hemiparasitic herbaceous epiphyte. SC: *8849*; occasional on *Prosopis, Condalia*.

Phoradendron capitellatum Torr. ex Trel. [*P. bolleanum* (Seem.) Eichler var. *capitellatum* (Torr. ex Trel.) Kearney & Peebles]. Mistletoe; hemiparastic herbaceous epiphyte. SC: *8685*, *8852*; common on *Juniperus*.

Phoradendron coryae Trel. Mistletoe; hemiparasitic herbaceous epiphyte. SC: *8868*; occasional on *Quercus oblongifolia*. SR: *8694*; occasional, on *Quercus* spp.

Phoradendron tomentosum (DC.) Engelm. ex A. Gray [*P. flavescens* (Pursh) Nutt. var. *pubescens* Engelm.]. Mistletoe, *inierto*; hemiparasitic herbaceous epiphyte. SC: *9018*; uncommon on *Fraxinus*.

Vitaceae

Vitis arizonica Engelm. Canyon grape, *parra del monte*; woody vine. SC: *9417*; occasional, canyons. SR: *9395*; locally common, Parker Canyon.

Zygophyllaceae

Kallstroemia grandiflora Torr. ex A. Gray. Mexican poppy, summer poppy, *baiburín, mal de ojo*; summer annual. SC: *8361*; occasional, canyons and slopes.

Kallstroemia parviflora Norton. Caltrop; summer annual. SR: *8339, 8713*; occasional, grasslands, Parker Canyon.

**Tribulus terrestris* L. Caltrop; summer annual. SR: *9591*; uncommon, disturbed sites.

MAGNOLIOPHYTA: LILIOPSIDA

Agavaceae

Agave palmeri Engelm. Palmer agave, *lechuguilla*; large leaf succulent. SC: occasional, canyons and rocky slopes. SR: uncommon, grasslands.

Agave parryi Engelm. var. *parryi*. Century plant; large leaf succulent. SR: uncommon, grasslands.

Agave schottii Engelm. var. *schottii*. Shindagger, *amolillo, amol*; small leaf succulent. SC: *9413*; abundant on uplands.

Yucca elata Engelm. Soap tree yucca, *palmilla*; caulescent leaf succulent. SC: *9408*; uncommon, canyons. SR: rare, a single individual observed in grassland west of ranch house.

Yucca schottii Engelm. Mountain yucca; caulescent leaf succulent. SC: uncommon, north- facing slope, Coal Mine Canyon. SR: rare, a single individual observed with oaks east of Santa Cruz River.

Yucca thornberi McKelvey. Banana yucca, *dátil*; acaulescent or short-caulescent leaf succulent. SC: abundant, uplands. Kartesz (1999) treats this as a variety of *Yucca baccata*; the latter taxon has strongly glaucous foliage, thick leaf fibers, and tends to form dense colonies of acaulescent rosettes. The plants of southern Arizona have green foliage, thinner fibers, and are often caulescent.

Alismataceae

Sagittaria longiloba Engelm. ex J. G. Sm. Arrowhead; emergent aquatic perennial. SC: *6488*, *J.Kaiser 1108* (ARIZ); collected four times from a cattle tank adjacent to Santa Cruz River, formerly "plentiful"; last collected in 1991.

Bromeliaceae

Tillandsia recurvata (L.) L. Ball moss, *gallitos*; epiphytic leaf succulent. SC: *8678*; locally abundant, found mostly on *Juniperus coahuilensis* in narrow canyons.

Commelinaceae

Commelina dianthifolia Delile. Day flower, *lágrima de Maria*; herbaceous perennial. SC: *8417*; uncommon, canyons and rocky slopes. SR: *8314*; common, grasslands.

Commelina erecta L. var. *angustifolia* (Michx.) Fern. Day flower, *yerba del pollo*; herbaceous perennial. SC: *8355*; uncommon, canyons and rocky slopes. SR: *9622*; uncommon, Parker Canyon.

Tradescantia pinetorum Greene. Spiderwort; herbaceous perennial. SR: *9565*; rare, grasslands.

Cyperaceae

Carex praegracilis W. Boott. Sedge, herbaceous perennial. SR: *9248*, *9253*, *9316*, *9463*; abundant, springs. San Rafael Valley collections are difficult to distinguish from *C. chihuahuensis* Mackenzie.

Cyperus dipsaceus Liebamann [*C. wrightii* Britton]. Flat sedge; herbaceous perennial. SC: *8405*; uncommon, north-facing slopes below oaks.

Cyperus esculentus L. Yellow nutsedge; herbaceous perennial. SC: *9672*; uncommon, canyons. SR: *9593*, *9598*, *9611A*; occasional, grasslands, roadsides.

Cyperus flavicomis Michx. [*C. albomarginatus* Mart. & Schrad.]. Flat sedge; herbaceous perennial. SC: *8467*, *8539*, *9647*; common along stream in Fresno Canyon.

Cyperus mutisii (Kunth) Griseb. Flat sedge; herbaceous perennial. SC: *9708*; rare, Fresno Canyon.

Cyperus niger Ruiz & Pavón. Flag sedge; herbaceous perennial. SC: *8776*; uncommon, Fresno Canyon. SR: *8324*, *8789*, *9599*; common, Santa Cruz River bottom.

Cyperus odoratus L. Flat sedge; herbaceous perennial. SC: *8495*, *9668*, *9684*; common in wet soil along Sonoita Creek. SR: *9668*; common, Santa Cruz River bottom.

Cyperus pallidicolor (Kukenthal) G. Tucker [*C. flavus* (Vahl) Nees, in part]. Flat sedge; herbaceous perennial. SC: *8438*; rare, below oaks.

Cyperus sphaerolepis Boeckl. [*C. rusbyi* Britt.]. Flat sedge; herbaceous perennial. SR: *8508*; occasional, oak savannas.

Cyperus squarrosus L. [*C. aristatus* Rottb.]. Flat sedge; annual. SC: *9497*, *9640*; uncommon, moist soil of canyon bottom.

Eleocharis bella (Piper) Svenson. Spike rush; summer annual. SR: *9575*; occasional, Santa Cruz River bottom.

Eleocharis montevidensis Kunth. Spike rush; herbaceous perennial. SC: *9320*; abundant along streams. SR: *9431*; abundant, springs, Santa Cruz River bottom.

Eleocharis palustris (L.) Roemer & J.A. Schultes [*E. macrostachya* Britton *sensu* Kearney & Peebles (1960), in part]. Spike rush, herbaceous perennial. SC: *9293*; occasional, mostly in canyons. SR: *9399*; abundant, springs, Santa Cruz River bottom.

Fimbristylis annua (All.) Roemer & J.A. Schultes [*F. baldwiniana* (Schultes) Torr.]. Summer annual. SC: *8539*; uncommon, canyon bottom.

Lipocarpa micrantha (Vahl) G. Tucker [*Hemicarpha micrantha* (Vahl) Pax]. Summer annual. SC: *9675*; uncommon, canyon bottom.

Schoenoplectus acutus (Muhl. ex Bigelow) A. & D. Löve ssp. *occidentalis* (S. Watson) S. G. Sm. [*Scirpus acutus* Muhl.]. Bullrush; herbaceous perennial. SR: *9461*; uncommon, springs.

Schoenoplectus americanus (Pers.) Volk. ex Schinz & R. Keller [*Scirpus americanus* Pers.] Bullrush; herbaceous perennial. SR: *9347*; uncommon, Santa Cruz River bottom.

Iridaceae

Sisyrinchium demissum Greene. Blue eye grass; herbaceous perennial. SR: *9316*; common, springs.

JUNCACEAE

Juncus bufonius L. Toad rush; annual. SC: *9113*, *9406*; common, moist soils of canyon bottom.

Juncus interior Wieg. Rush; herbaceous perennial. SC: *9236*, *9294*; uncommon, along streams.

Juncus mexicanus Willd. ex J.A. & J. H. Schultes. Rush; herbaceous perennial. SR: *9325*, *9388*,

9430, *9433*; abundant, springs, Santa Cruz River bottom.

Juncus saximontanus A. Nelson. Rush; herbaceous perennial. SC: *8493*, *9210*; uncommon, along streams. SR: *9315*, *9438*, *9464*, *9487*; common, springs, Santa Cruz River bottom.

Juncus torreyi Coville. Rush; herbaceous perennial. SR: *8284*, *9435*; common, springs, Santa Cruz River bottom.

Lemnaceae

Lemna gibba L. Windbags, duckweed; small floating aquatic. SC: rare, Fresno Canyon. SR: *8313*; occasional, springs. Usually found as a minor component in mixed colonies with *L. minor*.

Lemna minor L. Water lentil, duckweed; small floating aquatic. SC: *8499*; locally abundant in pools of canyons. SR: *8312*; common, springs.

Liliaceae

Allium kunthii G. Don. Wild onion; herbaceous perennial. SC: *9644*; rare, Coal Mine Canyon.

Calochortus ambiguus (M.E. Jones) Ownbey. Mariposa lily; herbaceous perennial. SC: *9282*; locally abundant, Fresno Canyon.

Calochortus kennedyi Porter var. *kennedy*. Desert mariposa; herbaceous perennial. SC: *9124*; occasional, uplands. SR: *9241*; locally common, grasslands.

Dichelostemma capitatum (Benth.) Wood ssp. *pauciflorum* (Torr.) G. Keator [*D. pulchellum* (Salisb.) Heller]. Bluedicks; herbaceous perennial. SC: *8929*; common, uplands. SR: *9106*; common, grasslands.

Echeandia flavescens (J.A. & H.H. Schultes) Cruden [*Anthericum torreyi* Baker]. Crag lily; herbaceous perennial. SR: *9528*, *9566*; uncommon, grasslands.

Milla biflora Cav. Mexican Star, herbaceous perennial. SC: rare, included based on a photo by R. Gagnon. SR: *9631*; rare, grasslands.

Nothoscordum texanum M.E. Jones. Herbaceous perennial. SC: *8440*, *9235*; uncommon, mostly in seeps in Coal Mine Canyon.

Nolinaceae

Dasylirion wheeleri S. Watson. Desert spoon, *sotol*; leaf rosette shrub. SC: common, rocky slopes.

Nolina microcarpa S. Watson. Beargrass, *sacahuista*, *palmilla*; leaf rosette shrub. SC: common, rocky slopes, grasslands. SR: locally abundant, grasslands and oak woodlands.

Poaceae

Agrostis exarata Trinius. Spike bent; herbaceous perennial. SR: *9439*; uncommon, Santa Cruz River bottom.

Alopecurus carolinianus Walt. Fox tail; summer annual. SR: *9255*; uncommon, springs.

Aristida adscencionis L. Six weeks three-awn; summer annual. SC: *8426*, *9229*; common, uplands. SR: *9588*; occasional, grasslands, roadsides.

Aristida divaricata Humb. & Bonpl. ex Willd. Three-awn; herbaceous perennial. SR: *9698*; occasional, grasslands.

Aristida purpurea Nutt. var. *fendleriana* (Steud.) Vasey [*A. fendleriana* Steud.]. Purple three-awn; herbaceous perennial. SR: *9374*; occasional, grasslands.

Aristida purpurea Nutt. var. *neallyi* (Vasey) Allred [*A. glauca* (Nees) Walp.]. SC: *9321*, *9543*; uncommon, uplands.

Aristida purpurea Nutt. var. *wrightii* (Nash) Allred [*A. wrightii* Nash]. Purple three-awn; herbaceous perennial. SC: *8573*; occasional, grasslands. SR: *9605*; common, grasslands.

Aristida ternipes Cav. var. *gentilis* (Henr.) Allred [*A. hamulosa* Henr.]. Spider grass; herbaceous perennial. SC: *8428*; common, canyons. SR: *8554*; common, grasslands.

Aristida ternipes Cav. var. *ternipes*. SC: *8505*, *8520*. Herbaceous perennial; common, canyons.

**Avena fatua* L. Wild oats; winter annual. SC: *9238*; rare, canyons. SR: *9264*; uncommon, disturbed areas.

**Avena sativa* L. Oats; winter annual. SR: *9152*; uncommon, disturbed areas.

Bothriochloa barbinodis (Lag.) Herter [*Andropogon barbinodis* Lag.]. Cane beardstem; herbaceous perennial. SC: *8430*; abundant, uplands. SR: *8329*; abundant, grasslands.

Bothriochloa laguroides (DC.) Herter ssp. *torreyana* (Steud.) Allred & Gould [*Andropogon saccharoides* Swartz]. Herbaceous perennial. SR: *9655*; uncommon, Sharp Spring drainage.

Bouteloua aristidoides (Kunth) Griseb. var. *aristidoides*. Six-weeks needle grama; summer annual. SC: *8434*; occasional, canyons and uplands. SR: *8572*; common, grasslands

Bouteloua chondrosioides (Kunth) Benth. ex S. Watson. Spruce-top grama; herbaceous perennial. SC: *8433*, *8502*; common, uplands. SR: *8708*; common, grasslands.

Bouteloua curtipendula (Michx.) Torr. Side oats grama; herbaceous perennial. SC: *8402*; abundant, canyons and uplands. SR: *8550*; abundant, grasslands, woodlands.

Bouteloua eludens Griffiths. Herbaceous perennial. SR: *9627*; rare, oak woodland adjacent to Parker Canyon.

Bouteloua eriopoda (Torr.) Torr. Black grama; herbaceous perennial. SC: *9637*; uncommon, uplands. SR: *9604*; uncommon, grasslands.

Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths. Blue grama; herbaceous perennial. SR: *9576*; abundant, grasslands.

Bouteloua hirsuta Lag. var. *hirsuta*. Hairy grama; herbaceous perennial. SC: *8429*; common, uplands. SR: *8574*; common, grasslands.

Bouteloua radicosa (E. Fourn.) Griffiths. Herbaceous perennial. SC: *8761*; occasional, uplands. SR: *9626*; uncommon, oak woodland adjacent to Parker Canyon.

Bouteloua repens (Kunth) Scribn. & Merr. [*B. filiformis* (Fourn.) Griffiths]. Slender grama; herbaceous perennial. SC: *8427*; common, uplands.

Bouteloua rothrockii Vasey. Rothrock grama; herbaceous perennial. SC: *8528A*; occasional, mesquite grasslands. SR: *9601*; occasional, low areas, sacaton flats.

Bromus anomalus Rupr. ex E. Fourn. Brome; herbaceous perennial. SR: *9696*; rare, Parker Canyon.

Bromus carinatus Hook. & Arn. California brome; herbaceous perennial. SC: *9215*, *9267*; common, gallery forests along Sonoita Creek.

**Bromus catharticus* Vahl. Brome; annual. SR: *9052*, *9158*, *9667*; common, Santa Cruz River floodplain, disturbed areas.

**Bromus japonicus* Thunb. ex Murr. Japanese brome; winter annual. SR: *9389*; common, Sharp Spring drainage.

Cenchrus spinifex Cav. [*C. pauciflorus* Benth.] Sandbur; summer annual. SC: *8667*; common, mostly in canyons, disturbed areas. SR: *8576*; common, grasslands.

Chloris virgata Swartz. Feather fingergrass; summer annual. SC: *8398B*; occasional, disturbed areas. SR: *8549*; occasional, grasslands, roadsides.

Cottea pappophoroides Kunth. Cotta grass; herbaceous perennial. SC: *9679*; rare, Fresno Canyon.

**Cynodon dactylon* (L.) Pers. Bermuda grass; herbaceous perennial. SC: *9284*; occasional, mostly along streams. SR: *9563*; occasional, roadsides, Santa Cruz River bottom.

Dasyochloa pulchella (Kunth) Willd. ex Rydberg [*Tridens pulchellus* (Kunth) Hitchc.]. Fluff grass; herbaceous perennial. SC: *9547*, *9648*; locally common, uplands.

Digitaria californica (Benth.) Henr. [*Trichachne californica* (Benth.) Chase]. Arizona cottontop; herbaceous perennial. SC: *8432*; uncommon, uplands. SR: *9609*; uncommon, grasslands.

Digitaria cognata (J.A. Schultes) Pilger var. *pubiflora* Vasey ex L.H. Dewey [*Leptoloma cognatum* (Schultes) Chase]. Fall witch grass; herbaceous perennial. SC: *9028*; uncommon, Coal Mine Canyon.

**Digitaria sanguinalis* (L.) Scop. Common crabgrass; summer annual. SC: *8660*; occasional, wet areas. SR: *9589*; occasional, disturbed areas.

**Echinochloa colona* (L.) Link. Jungle rice; summer annual. SC: *8537*; occasional, canyons.

**Echinochloa crus-galli* (L.) P. Beauv. Barnyard grass; summer annual. SC: *8452*, *8487*; occasional, along streams. SR: *8269*; common, Santa Cruz River bottom, abundant around cattle tanks.

Elionurus barbiculmis Hack. Herbaceous perennial. SC: *9710B*; rare, shaded slopes.

Elymus canadensis L. Wild rye; herbaeous perennial. SR: *9436*; common, Santa Cruz River bottom, springs.

Elymus elymoides (Raf.) Swezey [*Sitanion hystrix* (Nutt.) J. G. Smith]. Bottlebrush squirrel tail; herbaceous perennial. SC: *9118*; occasional, canyons, slopes. SR: *9263*; occasional, Sharp Spring drainage.

Enneapogon desvauxii Desv. ex Beauv. Spike pappusgrass; summer annual. SC: *8474*, *8482*; uncommon, rocky slopes. SR: *8711*; uncommon, grasslands.

**Eragrostis cilianensis* (All.) Vign. ex Janchen. Stink grass; annual. SC: *8450*; mostly in heavily

grazed areas. SR: *8246*; occasional, disturbed areas.

**Eragrostis curvula* (Schrad.) Nees var. *conferta* Stapf. Weeping lovegrass; herbaceous perennial. SC: *9277*; uncommon, canyons.

Eragrostis intermedia Hitchc. Plains lovegrass; herbaceous perennial. SC: *8439*; common, uplands. SR: *8548*; abundant, grasslands.

**Eragrostis lehmanniana* Nees. Lehmann lovegrass; herbaceous perennial. SC: *9499*; occasional, mostly overgrazed saddles. SR: *9483*; locally common, grasslands.

Eragrostis pectinacea (Michx.) Nees ex Steud. var. *pectinacea* [*E. diffusa* Buckley]. Summer annual. SC: *8530, 9495*; occasional, canyons. SR: *9606, 9612*; occasional, grasslands, washes.

Eriochloa acuminata (Presl) Kunth var. *acuminata* (Vasey) R.B. Shaw [*E. gracilis* (Fourn.) Hitchc. var. *gracilis* (Vasey) Hitchc.]. Cupgrass; summer annual. SC: *8375*; common, gallery forests, canyons.

Eriochloa acuminata (Presl) Kunth var. *minor* (Vasey) R.B. Shaw [*E. gracilis* (Fourn.) Hitchc. var. *minor* (Vasey) Hitchc.]. Cupgrass; summer annual. SR: *8247*; abundant, grasslands.

**Festuca arundinacea* Schreber. [*F. elatior* L.]. Meadow fescue; herbaceous perennial. SR: *9299, 9314, 9352*; abundant, springs.

Heteropogon contortus (L.) Beauv. ex Roemer & J.A. Schultes. Tangle head; herbaceous perennial. SC: *8770*; common, rocky slopes.

Heteropogon melanocarpus (Ell.) Ell. ex Benth. Sweet tangle head; summer annual. SC: *8396*; common, rocky slopes. SR: *8702*; occasional, oak savannas.

Hilaria belangeri (Steud.) Nash var. *belangeri*. Curly mesquite grass; herbaceous perennial. SC: *8816*; locally abundant, grasslands. SR: *9581*; occasional, grasslands.

Hordeum jubatum L. ssp. *jubatum*. Foxtail; herbaceous perennial. SR: *9308B, 9349*; common, springs, low areas.

**Hordeum murinum* L. ssp. *leporinum* (Link) Arcang. Wild barley; winter annual. SR: *9049*; occasional, margins of cattle tanks.

Hordeum pusillum Nutt. Little barley; annual. SR: *9308A*; uncommon, margins of cattle tanks.

Leersia oryzoides (L.) Sw. Rice cutgrass; herbaceous perennial. SR: *8783, 8786*; uncommon, Sharp Spring.

Leptochloa dubia (Kunth) Nees. Green sprangletop; herbaceous perennial. SC: *8421*; uncommon, rocky slopes. SR: *8707*; occasional, grasslands.

Leptochloa fusca (L.) Kunth ssp. *fascicularis* (Lam.) N. Snow [*L. fascicularis* (Lam.) A. Gray var. *fascicularis*]. Beaded sprangletop; summer annual. SR: *8575, 8582*; occasional, grasslands, disturbed areas.

Leptochloa panicea (Retz.) Ohwi ssp. *brachiata* (Steudl.) N. Snow [*L. filiformis* Lam.]. Summer annual. SC: *8529*; common, canyons.

Leptochloa viscida (Scribn.) Beal. Summer annual. SC: *9496*; occasional, mostly in canyons. SR: *9596*; uncommon, washes.

Lycurus setosus (Nutt.) C. G. Reeder [*L. phleoides* Kunth *sensu* Kearney and Peebles (1960), in part]. Wolf-tail; herbaceous perennial. SC: *8425*; common, uplands. SR: *9570*; abundant, grasslands.

**Melinis repens* (Willd.) Zizka [*Rhynchelytrum roseum* (Nees) Stapf & C. E. Hubbards ex Bews]. Natal grass; herbaceous perennial. SC: *8813*; rare, canyons. SR: *9736*; rare, Parker Canyon.

Muhlenbergia arizonica Scribn. Herbaceous perennial. SC: *8760, 9078*; locally abundant, uplands. SR: *9658*; uncommon, grasslands.

Muhlenbergia asperifolia (Nees & Meyen ex Trinius) Parodi. Scratchgrass; herbaceous perennial. SR: *9656*; locally abundant, Sharp Spring drainage.

Muhlenbergia emersleyi Vasey. Bullgrass; herbaceous perennial. SC: *8676, 8762*; occasional, mostly north-facing slopes.

Muhlenbergia fragilis Swallen. Summer annual. SC: *8448*; occasional, canyons and rocky slopes. SR: *8730, 9725*; uncommon, oak woodland adjacent to Parker Canyon.

Muhlenbergia rigens (Benth.) Hitchc. Deer grass; herbaceous perennial. SC: *8764*; abundant, canyon bottom. SR: *9686*; occasional, drainages.

Muhlenbergia tenuifolia (Kunth) Trinius [*M. monticola* Buckley]. Herbaceous perennial. SC: *9642A, 9676, 9705*; occasional, rock walls.

Panicum bulbosum Kunth. Bulb panicum; herbaceous perennial. SC: *8378, 8501*; uncommon, canyons. SR: *9628*; uncommon, oak woodland adjacent to Parker Canyon.

Panicum hallii Vasey var. *hallii*. Herbaceous perennial. SR: rare, grasslands.

Panicum hirticaule J. Presl. Summer annual. SC: *8391, 8395, 8449*; common, canyons and slopes. SR: *8285*; common, grasslands.

Panicum obtusum Kunth. Vine mesquite; herbaceous perennial. SC: *9549*; uncommon, washes. SR: *9578*; occasional, grasslands, springs.

**Paspalum dilatatum* Poir. Dallis grass; herbaceous perennial. SC: *8664*; common, streams. SR: *8327*; occasional, Sharp Spring.

Paspalum distichum L. Knotgrass; herbaceous perennial. SR: *8788*; locally common, Santa Cruz River bottom.

Paspalum setaceum Michx. [*P. stramineum* Nash]. Herbaceous perennial. SR: *8705, 9595*; uncommon, oak savannas.

Phalaris caroliniana Walt. Canary grass; annual. SR: *9309, 9428*; occasional, low areas.

**Phalaris minor* Retzius. Littleseed canary grass; annual. SC: *9204*; uncommon, canyons.

Poa bigelovii Vasey & Scribn. Bigelow's bluegrass; winter annual. SC: *8863*; common, canyons, rocky slopes.

**Poa pratensis* L. ssp. *pratensis*. Kentucky bluegrass; herbaceous perennial. SR: *9256*; abundant, Sharp and Heron springs drainages.

**Polypogon monspeliensis* (L.) Desf. Rabbitfoot grass; annual. SC: *9147*; common along streams. SR: *9099, 9372*; common, Santa Cruz River bottom.

**Polypogon viridis* (Gouan) Breistr. [*Agrostis semiverticillata* (Forsk.) C. Christens.]. Water bent; herbaceous perennial. SC: *9331, 9356*; uncommon, along streams. SR: *9466*; uncommon, Sharp Spring.

Schizachyrium cirratum (Hack.) Wooton & Standley [*Andropogon cirratus* Hack.]. Texas bluestem; herbaceous perennial. SR: *9668*; locally abundant, grasslands.

Schizachyrium sanguineum (Retzius) Altson var. *hirtiflorum* (Nees) Hatch [*Andropogon hirtiflorum* (Nees) Kunth]. Herbaceous perennial. SC: *8545, 9681, 9710A*; occasional, canyons, shaded slopes. SR: *8785*; occasional, north-facing slopes.

Setaria grisebachii E. Fourn. Grisebach bristlegrass; summer annual. SC: *8538*; occasional, north- facing slopes. SR: *8792, 9620A*; occasional, Parker Canyon.

Setaria leucopila (Scribn. & Merr.) K. Schum. [*S. macrostachya* Kunth *sensu* Kearney and Peebles (1960), in part]. Plains bristle grass; herbaceous perennial. SC: *8441, 8528B*; occasional, mesquite grasslands.

**Sorghum halepense* (L.) Pers. Johnson grass; herbaceous perennial. SC: *9652*; occasional, mostly along Sonoita Creek. SR: *9561*; locally abundant, roadsides, springs, Santa Cruz River floodplain.

Sphenopholis obtusata (Michx.) Scribn. Prairie wedge grass; herbaceous perennial. SR: *9460*; uncommon, springs.

Sporobolus contractus Hitchc. Spike dropseed; herbaceous perennial. SC: *9635*; occasional, along Sonoita Creek. SR: *9624*; rare, Parker Canyon.

Sporobolus cryptandrus (Torr.) A. Gray. Sand dropseed; herbaceous perennial. SR: *9592, 9611B, 9695*; uncommon, grasslands, washes.

Sporobolus wrightii Munro ex Scribn. Sacaton. Herbaceous perennial. SC: rare, canyons. SR: *9562*; abundant on Santa Cruz River floodplain.

Trachypogon spicatus (L.) Kuntze [*T. secundus* (J. Presl) Scribn.]. Crinkle-awn; herbaceous perennial. SC: *8536, 8769*; occasional, north-facing slopes. SR: *9608, 9664*; common, grasslands.

Urochloa arizonica (Scribn. & Merr.) O. Morrone & F. Zuloaga [*Panicum arizonicum* Scribn. & Merr.]. Summer annual. SC: *9671*; rare, canyons. SR: *8254*; occasional, low areas.

Vulpia microstachys (Nutt.) Munro var. *pauciflora* (Scribn. ex Beal) Lonard & Gould [*Festuca pacifica* Piper]. Winter annual. SC: *8870*; occasional, rocky slopes.

Vulpia octoflora (Walt.) Rydb. var. *hirtella* (Piper) Henr. [*Festuca octoflora* Walt. var. *hirtella* Piper]. Six-weeks fescue; winter annual. SC: *8923*; occasional, rocky slopes. SR: *9095*; occasional, grasslands.

Vulpia octoflora (Walt.) Rydb. var. *octoflora*. Six-weeks fescue; winter annual. SC: *9081*; common, grasslands, sandy soils along Sonoita Creek.

Pontederiaceae

Heteranthera limosa (Sw.) Willd. Mud plantain;

emergent aquatic perennial. SR: *6489*; last collected from pond adjacent to Santa Cruz River in 1991.

Potamogetonaceae

Potamogeton foliosus Raf. Pondweed; submerged aquatic perennial. SR: *9462*, *9465*; uncommon, Sharp and Heron springs.

Typhaceae

Typha domingensis Pers. Cattail; emergent perennial aquatic. SC: rare, a single small population seen along Sonoita Creek. SR: *9574*; uncommon, Santa Cruz River bottom.

Zannichelliaceae

Zannichellia palustris L. Horned pondweed, common poolmat; submerged herbaceous aquatic. SC: *9332*; rare, found once in pool along Sonoita Creek. SR: *9245*; common, springs, Santa Cruz River.

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ANNOTATED CHECKLIST OF THE VASCULAR FLORA OF THE BIG SANDY CREEK UNIT, BIG THICKET NATIONAL PRESERVE, TEXAS

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ABSTRACT

An annotated, vouchered checklist is provided of the vascular plant taxa of the 5,806 hectare Big Sandy Creek Unit, Big Thicket National Preserve, Polk County, southeastern Texas. Documented for the unit are 693 total taxa with 45 of them exotic.

RESUMEN

Se ofrece un listado con anotaciones, y testigos de los taxa de plantas vasculares de las 5,806 hectáreas de Big Sandy Creek Unit, Big Thicket National Preserve, Polk County, Sureste de Texas. Se documentan para la unidad un total de 693 de los que 45 son exóticas.

INTRODUCTION

This is the third installment of an inventory, based upon available voucher specimens, of the vascular flora of the Big Thicket National Preserve, southeastern Texas. In the two previous papers we provided an annotated checklist of the Hickory Creek and the Turkey Creek units (MacRoberts et al. 2002b; Brown et al. 2005.). In this paper we do the same for the Big Sandy Creek Unit.

SITE AND METHODS

The Big Thicket is located mostly within the longleaf pine region of the West Gulf Coastal Plain in southeastern Texas (Parks & Cory 1936; McLeod 1971; Harcombe & Marks 1979; Marks & Harcombe 1981; Harcombe et al. 1993). The Big Thicket National Preserve consists of 12 units scattered over seven Texas

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counties. The units range from 222 to 10,100 hectares and total about 34,000 hectares (Peacock 1994). The Big Sandy Creek Unit consists of 5,806 hectares and is located in eastern Polk County (Fig. 1). It is about 14.5 km from north to south and is about 9.7 km at its widest east-west point. In elevation it ranges from about 53 to 94 meters. The Big Sandy Creek Unit was chosen for inclusion in the Big Thicket National Preserve because it is diverse, has a wide range of plant communities, is a stream corridor unit, and has "hilly" topography absent from most of the other units (Ajilvsgi 1979; Watson 1979; Harcombe & Marks 1981). It is dominated by upper slope pine oak forest, mid slope oak pine forest, and lower slope hardwood pine forest. Also present are upland pine forest, floodplain hardwood forest, floodplain hardwood pine forest, baygall, cypress-tupelo swamp, and sandhill pine forest (Harcombe & Marks 1979). It has one pitcher plant bog that is badly degraded , no wetland pine savanna, no prairies, and no xeric sandylands although some of the upper slope pine oak forest and sandhill pine forest approach xeric sandylands conditions. A map showing the distribution of plant community types is in Harcombe and Marks (1979). Fire suppression over the past 30 years has resulted in extensive midstory development and shading out of herbaceous vegetation. Details regarding soils, topography, and climate can be found in Deshotels (1978), Watson (1979), Harcombe and Marks (1979), and Marks and Harcombe (1981).

Like all units of the Big Thicket National Preserve, the Big Sandy Creek Unit had not previously been the subject of a detailed floristic inventory although it is one of the best documented units (Watson 1982).

The MacRoberts collected 446 specimens, representing 348 taxa, during 11 field days beginning 3 April 2003 and ending 2 May 2004. Larry Brown collected 644 specimens , representing 435 taxa, during 12 field days beginning 4 April 2003 and ending 27 September 2005. Stanley Jones collected 252 specimens in 2003. Geraldine Watson collected 255 specimens over several years in the late 1970s and early 1980s. Other collectors gathered about 84 specimens. We searched the Texas A & M University (TAMU) herbarium consortium database for additional specimens but no new taxa were found there.

Since our purpose is to produce a list of documented taxa known to occur on the Big Sandy Creek Unit, a vouchered specimen was considered to be the only evidence acceptable for inclusion in the list. However, two species, *Phlox nivalis* subsp. *texensis* a federally listed species, and *Utricularia inflata* were photographically documented and not collected. In all, about 1,650 herbarium specimens form the data for this report. All specimens have been annotated by Larry Brown including most of Bill Carr's 21 collections at TEX/LL. All 6 of his single taxa records have been examined and annotated.

In most cases, nomenclature follows Jones et al. (1997) and Kartesz and Meacham (1999). Some recent literature sources were followed, especially some

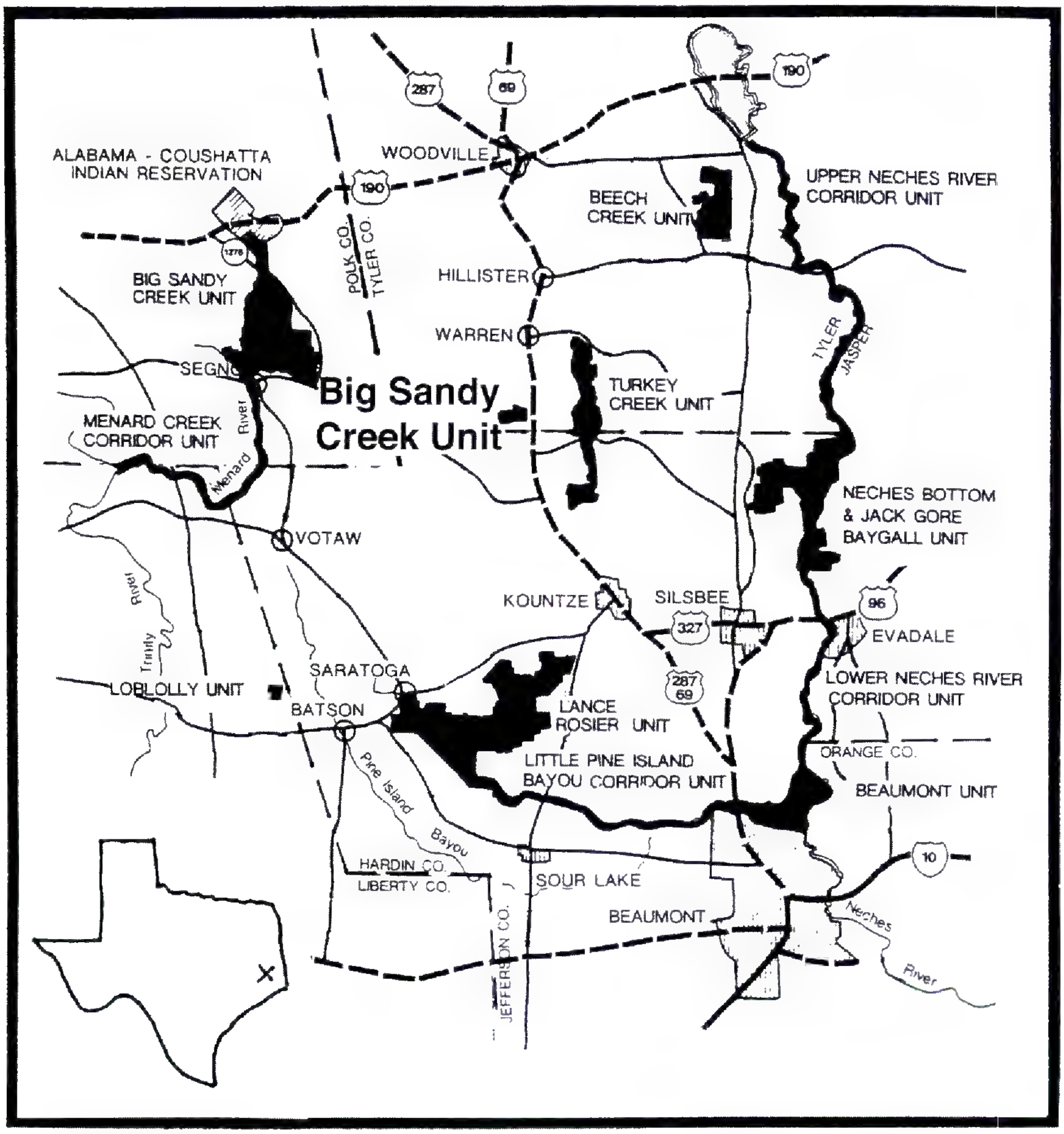


Fig. 1. Location of Big Sandy Creek Unit, Big Thicket National Preserve, Texas.

nomenclature in the *Flora of North America* volumes. In cases of multiple collections, no more than four are listed for each taxon.

RESULTS

Table 1 is an annotated list of the Big Sandy Creek Unit taxa. The following abbreviations are used in Table 1.

CL = C. Liu. His specimen is at Rice University.
CP = Charles Peterson. His two specimens are at SBSC.
DR= David Rosen. His 12 specimens are at SBSC.
GW = Geraldine Watson. Her specimens are at Rice University.

LB = Larry Brown. His specimens are currently at Rice University except for those few that are indicated to be at SBSC.
MM = Barbara and Michael MacRoberts. Their specimens are currently at Rice University except for one at SBSC.
PR = Paul Rolling. His collections are a clear picture of *Utricularia inflata* from the Beaverslide Trail. There is no doubt as to its identification. One specimen is at SBSC and a duplicate is currently at Rice University
SEWP = Sandra Elsik and Warren Pruess. Their specimens are currently at Rice University.
SJ = Stanley Jones. His specimens are currently at Rice University.
WRC = Bill Carr. His 21 specimens are at TEX/LL.
* = exotic
+ = see notes at end of list

Those specimens listed as currently at Rice University are mounted and will be deposited at a yet to be selected major Texas herbarium. Except for the Stanley Jones specimens, they were collected under National Park Service Cooperative Agreement No. CA 14001004.

ACANTHACEAE

Hygrophila lacustris (Schlecht. & Cham.) Nees, SJ 16290;MM6929; LB 28616; GW 2582
Justicia ovata (Walter) Lindau var. *lanceolata* (Chapm.) R.W. Long, SJ 16240; LB 28170
Ruellia humilis Nutt., SJ 16340; LB 28760, 28219; GW 2579

ACERACEAE

Acer barbatum Michx., SJ 16242; LB 27804; GW 2446
Acer rubrum L., SJ 16099; MM 6091; LB 27804, 28147

AGAVACEAE

Manfreda virginica (L.) Salisb. ex Rose, LB 28995, 28775
Yucca louisianensis Trel., LB 27791; SJ 16429

ALISMATACEAE

Echinodorus cordifolius (L.) Griseb., LB 28622
Sagittaria latifolia Willd., GW 2802

AMARANTHACEAE

Froelichia floridana (Nutt.) Moq., MM 6709

ANACARDIACEAE

Rhus aromatica Aiton var. *aromatica,* LB 28669; MM 6598;GW 2730
Rhus copallinum L., SJ 16392; MM 6081
Rhus glabra L., LB 28683
Toxicodendron radicans (L.) Kuntze, LB 27802
Toxicodendron vernix (L.) Kuntze SJ 16188

ANNONACEAE

Asimina parviflora (Michx.) Dunal, SJ 16093; LB 28146, 28188

APIACEAE

Centella erecta (L.f.) Fernald, SJ 17408; LB 28629; MM 6256
Chaerophyllum tainturieri Hook. var *dasycarpum* S. Watson, MM 6324
Chaerophyllum tainturieri Hook. var. *tainturieri*, LB 27843
Cicuta maculata L., GW 3502
**Cyclospermum leptophyllum* (Pers.) Sprague ex Britton & Wilson, LB 28214
Cynosciadium digitatum DC., SJ 16429; GW 2041
Eryngium prostratum Nutt. ex DC., LB 28226
Hydrocotyle verticillata Thunb., SJ 16236; LB 28657, 28243; GW 2606
Ptilimnium capillaceum (Michx.) Raf., SJ 16362; GW 2588, GW *2596*
Sanicula canadensis L., MM 6275, 6571; LB 28144; GW 2482
Sanicula smallii Bickn., SJ 16186
Spermolepis divaricata (Walter) Raf. ex Ser., SJ 16381; MM 6616
Spermolepis echinata (DC.) Heller, MM 61444
Thaspium trifoliatum (L.) A. Gray var. *aureum* Britton, GW 2470
Trepocarpus aethusae Nutt. ex DC., SJ 16254; LB 28651

APOCYNACEAE

Trachelospermum difforme (Walter) A. Gray, LB 28790

AQUIFOLIACEAE

Ilex ambigua (Michx.) Torr., SJ 16233; LB 30452 (SBSC)

Ilex coriacea (Pursh) Chapm., LB 28955, 28148, 28195; MM 6257

Ilex decidua Walter, GW 2460,2693b, 2694, 2881

Ilex longipes Chapm. ex Trel., SJ 16173; GW 2466, 2882, LB 30460 (SBSC)

Ilex opaca Soland., LB 28595, 28189, 28734; MM 6100

Ilex vomitoria Aiton, SJ 16095; MM 6121

ARACEAE

Arisaema dracontium (L.) Schott, MM 6346; LB 28346

Arisaema triphyllum (L.) Schott, LB 28242, 28621; MM 6258, GW 2533

Peltandra virginica (L.) Schott, SJ 16294; GW 2464a, 2462a, 2641

ARALIACEAE

Aralia spinosa L., SJ 16097; LB 28786; MM 6341

**Hedera helix* L., LB 28143

ARECACEAE

Sabal minor (Jacq.) Pers., SJ 16079; MM 6073; LB 28138

ARISTOLOCHIACEAE

Aristolochia reticulata Jacq., MM 6315; LB 28240

Aristolochia serpentaria L., LB 28972; MM 6276, 6549; GW 2017

Aristolochia tomentosa Sims, GW 2511

ASCLEPIADACEAE

Asclepias amplexicaulis Michx., SJ 16369; LB 28374; MM 6699

Asclepias perennis Walter, LB 30535 (SBSC)

Asclepias tuberosa Woodson subsp. *interior* Woodson, SJ 16302

Asclepias variegata L., MM 6280; LB 28364

Asclepias verticillata L., LB 28779; GW 2016

Asclepias viridis Walter, MM 6310

Matelea cynanchoides (Engelm.) Woodson, MM 6562

Matelea decipiens (Alex.) Woodson, SJ 16182; LB 28662; MM 6738; GW 2570

Matelea gonocarpos (Walter) Shinners, SJ 16415; LB 28332;GW 2019

ASPLENIACEAE

Asplenium platyneuron (L.) Britton, Sterns & Poggenb., LB 28619, 28382; MM 6131

ASTERACEAE

Ambrosia artemisiifolia L., LB 28672, 28719

Ambrosia psilostachya DC., MM 6886; LB 28996

Baccharis halimifolia L., LB 28950; GW 2735

Berlandiera pumila (Michx.) Nutt. var. *pumila*, MM 6285, LB 27801

Berlandiera pumila (Michx.) Nutt. var. *scabrella* Nesom & B.L. Turner, LB 28431a; MM 6605

Bidens bipinnata L., *MM 6933:* LB 28723

Bidens discoidea (Torr. & A. Gray) Britton, LB 28615

Bidens frondosa L., MM 6934; GW N08, 2778b

Boltonia diffusa Elliott, MM 6907, 6727

Chrysopsis mariana (L.) Elliott, LB 28943

Chrysopsis pilosa Nutt., LB 28674, 28778; MM 6614, 6611

Cirsium horridulum Michx., MM 6152

Conoclinium coelestinum (L.) DC., MM 6891: LB 28937

Conyza canadensis (L.) Cronquist var. *canadensis*, LB 28761

Conyza canadensis (L.) Cronquist var. *pusilla* (Nutt.) Cronquist, LB 28415; MM 6708; GW 2770

Coreopsis lanceolata L., MM 6145

Coreopsis tinctoria Nutt., MM 6536

Croptilon divaricatum (Nutt.) Raf., LB 29001; MM 6704; WRC 10827

+*Croptilon hookerianum* (Torr. & A. Gray) House, GW 2688

+*Diaperia candida* (Torr. & A. Gray) Bentham, MM 7049

Echinacea pallida (Nutt.) Nutt. var. *sanguinea* (Nutt.) *Gandhi* & R.D. Thomas, SJ 16402; LB 28223a; MM 6547

Elephantopus carolinianus Raeusch., MM 6946: WRC 10831

Elephantopus nudatus A. Gray, MM 6896

Elephantopus tomentosus L., LB 28598a, 28353; MM 6710, 6560

Erechtites hieraciifolia (L.) Raf. ex DC., LB 28960

Erigeron annuus (L.) Pers., GW 2620

Erigeron strigosus Muhl. ex Willd., LB 28153, MM 6084, 6107; GW 2574

Eupatorium capillifolium (Small) Lam., LB 28935

Eupatorium lancifolium (Torr. & A. Gray) Small, LB 28756

Eupatorium leucolepis (DC.) Torr. & A. Gray, MM 6730, 6594
Eupatorium perfoliatum L., LB 28613; MM 6344
Eupatorium rotundifolium L., LB 28427; MM 6729
Eupatorium serotinum Michx., LB 28742, 28228
Euthamia leptocephala (Torr. & A. Gray) Greene ex Porter & Britton, LB 28962, 28746
Facelis retusa (Lam.) Schultz-Bip., LB 27845a; GW 2490
Gaillardia aestivalis (Walter) H. Rock var. *aestivalis*, LB 28680
Gaillardia pulchella Foug. var. *pulchella*, MM 6236
Gamochaeta coarctata (Willd.) Kerguelen, LB 30451a (SBSC)
Gamochaeta pensylvanica (Willd.) Cabrera, GW 2585a
Gamochaeta purpurea (L.) Cabrera, MM 6102; LB 27786, 30537; WRC 17345
Helenium amarum (Raf.) H. Rock var. *amarum*, MM 6545
Helianthus angustifolium L., LB 2894*7*
Helianthus hirsutus Raf., LB 28402; MM 6750, 6524
Helianthus mollis Lam., LB 28676, 20400; MM 6749, 6519
Helianthus simulans E. E. Wats., LB 30877
Heterotheca subaxillaris (Lam.) Britton & Rusby, LB 28932, 28770; WRC 10828
Hieracium gronovii L., LB 28594; MM 6565
Hymenopappus artemisiifolius DC. var. *artemisiifolius*, SJ 16260; LB 28122; MM 6085
**Hypochaeris microcephala* (Sch. Bip.) Cabrera var. *albiflora* (Kuntze) Cabrera, MM 6265
Iva annua L., GW 2052
Krigia cespitosa (Raf.) Chambers, GW 2493
Krigia virginica (L.) Willd., MM 6111; LB 27782
Lactuca canadensis L., LB 28409, 28378; MM 6518, 6559
Liatris acidota Engelm. & A. Gray, MM 6917
Liatris elegans (Walter) Michx. var. *elegans*, MM 6917,6747; LB 28984, 28762
Liatris squarrosa (L.) Michx., var. *hirsuta* (Rydb.) Gaiser, LB 28990, 28684
Liatris squarrosa (L.) Michx var. *squarrosa*, MM 5715, 6746; GW 2092, 2732
Mikania scandens (L.) Willd., LB 27807
Oligoneuron nitidum (Torr. & A. Gray) Small, LB 28985, 28396; MM 6690, 6520
Packera glabella (Poir.) C. Jeffrey, SJ 16237; MM 6342; GW 2526
Packera obovata (Muhl. ex Willd.) W. A. Weber & A. Love, LB 27805
Pityopsis graminifolia (Michx.) Nutt., MM 6898, 6080; LB 28772
Pluchea camphorata (L.) DC., LB 28934; GW 2785
Pluchea foetida (L.) DC., LB 28710
Pseudognaphalium obtusifolium (L.) Hillard & Burtt, LB 28934, 28673; MM 6716
Pyrrhopappus carolinianus (Walter) DC., MM 6313; SJ 15348
Ratibida columnifera (Nutt.) Woot. & Standl., MM 6543
Rudbeckia hirta L., *MM 6278; LB 28200; SJ16353*
Smallanthus uvedalius (L.) Mack. ex Small, LB 28729a
Solidago canadensis L., LB 28968; GW 2885
Solidago ludoviciana (A. Gray) Small, LB 28749, 28334, 27801a; MM 6294
Solidago odora Aiton var. *odora*, LB 28942, 28660
Solidago petiolaris Aiton., LB 29018
Solidago rugosa Mill. subsp. *asper* (Aiton) Cronquist, LB 28946, 22873
Solidago rugosa Mill. subsp. *rugosa*, LB 28752, GW 2424, 2423A; CL 901179
**Soliva sessilis* Ruiz & Pavon., GW 2476
**Sonchus asper* (L.) Hill, LB 29012
**Sonchus oleraceus* L., LB 28118
Symphyotrichum dumosum (L.) Nesom, LB 28936a
Symphyotrichum patens (Aiton) Nesom, LB 28981, 27776
Symphyotrichum pratense (Raf.) Nesom, MM 6909
Verbesina virginica L., LB 28780
Vernonia missurica Raf., LB 30766 (SBSC)
Vernonia texana (A. Gray) Small, MM 6725, 6527; LB 28731; GW 2731
**Youngia japonica* (L.) DC., LB 27839

BERBERIDACEAE

Podophyllum peltatum L., MM 6151

BETULACEAE

Alnus serrulata (Aiton) Willd., SJ 16144; LB 28172
Betula nigra L., *SJ 16297;* MM 6328; LB 28249a
Carpinus caroliniana Walter, MM 6538, 6148
Ostrya virginiana (Mill.) K. Koch, SJ 16072, 16440; LB 28131; MM 6525

BIGNONIACEAE

Bignonia capreolata L., LB 27834a

Campsis radicans (L.) Seem. ex Bureau, SJ 16422
Catalpa speciosa (Warder) Warder ex Engelm., SJ 16321; LB 27775

BLECHNACEAE
Woodwardia areolata (L.) T. Moore, MM 6338; LB 27846

BORAGINACEAE
Cynoglossum virginianum L., GW 1846
Lithosperma tuberosum Rugel ex DC., GW 2213
Myosotis macrosperma Engelm., GW 2491

BROMELIACEAE
Tillandsia usneoides (L.) L., MM 6936, 6330, 6755

BUDDLEJACEAE
Polypremum procumbens L., MM 6566

BURMANNIACEAE
Apteria aphylla Nutt., LB 28782; CP 1041; DR 2373
Burmannia capitata (J.F. Gmel.) Mart., MM 6863

CABOMBACEAE
Brasenia schreberi J.F. Gmel., SJ 16291

CACTACEAE
Opuntia humifusa (Raf.) Raf., SJ 16383; MM 6603

CALLITRICHACEAE
Callitriche heterophylla Pursh, SJ 16147; GW 2527

CAMPANULACEAE
Lobelia appendiculata A. DC., MM 6303; GW 2562
Lobelia cardinalis L., LB 28978
Lobelia puberula Michx., MM 6878; GW 2822; LB 28958, 28606
Triodanis perfoliata (L.) Nieuwl., GW 2475
**Wahlenbergia marginata* (Thunb.) A. DC., SJ 16376; MM 6106; LB 27780

CAPRIFOLIACEAE
**Lonicera japonica* Thunb., MM 6263; LB 28156
Lonicera sempervirens L., LB 27815; GW 2469
Sambucus nigra L. subsp. *canadensis* (L.) R. Bolli, LB 28641
Viburnum acerifolium L., SJ 16322
Viburnum dentatum L., SJ 16396: MM 6074; LB28593; GW2465
Viburnum nudum L. var. *nudum*, SJ 16286; LB 28198
Viburnum rufidulum Raf., MM 6093; GW 2040, 2703

CARYOPHYLLACEAE
+Cerastium pumilum* Curtis, MM 6143 (SBSC)
Loeflingia squarrosa Nutt., MM 7072
+Minuartia muscorum (Fassett) Rabeler, SJ 16105
+Silene subciliata B. L. Robins., LB 28599, 28626

CELASTRACEAE
Euonymus americanus L., MM 6071; LB 28163

CHENOPODIACEAE
Dysphania ambrosioides (L.) Mosyakin & Clements, LB 28646

CISTACEAE
Helianthemum carolinianum (Walter) Michx., LB 28235a, 27797; MM 6110
Lechea mucronata Raf., LB 27783
Lechea tenuifolia Michx., SJ 16360; LB 28229; MM 6609

COMMELINACEAE
Commelina erecta L., MM 6601, LB 28385, 28169; SJ 126343
Commelina virginica L., LB 29035; MM 6940
Tradescantia reverchonii Bush, MM 6267

CONVOLVULACEAE
Dichondra carolinensis Michx., MM 6125; LB 27784 SJ 16355
Ipomoea cordatotriloba Dennst., LB 28333
Ipomoea lacunosa L., LB 28735
Ipomoea pandurata (L.) G. F. W. Mey., LB 28429; MM 2753, 6617, 6570
Stylisma pickeringii A. Gray var. *pattersonii* (Fernald & B.G. Schub.) Myint, MM 6611

CORNACEAE
Cornus florida L., LB 28154; MM 6105; SJ 16394
Nyssa aquatica L., SJ 16205, 16256; LB 28134, 30455 (SBSC)
Nyssa biflora Walter, SJ 16317; LB 28322
Nyssa sylvatica Marshall., MM 6429; LB 28759, 30540 (SBSC); SJ 16087

CUPRESSACEAE
Juniperus virginiana L., *MM 6114;* LB 28598, 28356; SJ 16410
Taxodium distichum (L.) L. C. Rich., SJ 16209, 16339

CUSCUTACEAE
Cuscuta compacta Juss. ex Choisy, LB 30765 (SBSC)

CYPERACEAE
Bulbostylis ciliatifolia (Elliott) Fernald var *ciliatifolia*, MM 6889
Bulbostylis ciliatifolia (Elliott) Fernald var *coarctata* (Elliott) Kral , SJ 16425;

Carex abscondita Mack., SJ 16119; LB 30456 (SBSC)
Carex albicans Willd. ex Spreng. subsp. *australis* (Bailey) J.H. Rettig, LB 27835
Carex albolutescens Schwein., LB 30566
Carex atlantica Bailey subsp. *capillacea* (Bailey) Reznicek, MM 6244; LB 28191
Carex basiantha Steud., SJ 16116
Carex blanda Dewey, SJ 16124
Carex caroliniana Schwein, SJ 16115; LB 27820
Carex cephalophora Muhl. ex Willd., SJ 16121
Carex cherokeensis Schwein., SJ 16123
Carex complanata Torr. & Hook., MM 6279, 6529; WRC 17335
Carex corrugata Fernald, SJ 16124; LB 27840
Carex crebriflora Wieg., SJ 16041; LB 27836
Carex debilis Michx. var. *debilis,* SJ 16117; LB 28181
Carex digitalis Willd. var. *asymetrica* Fernald, SJ 16160
Carex festucacea Schkuhr ex Willd., SJ 16044
Carex floridana Schwein., SJ 16044.
Carex frankii Kunth, SJ 16245
Carex glaucescens Elliott, LB 28597, 28266
Carex intumescens Rudge, LB 27150
Carex joorii Bailey, MM 6697; LB 28959a
Carex leavenworthii Dewey, SJ 16103;
Carex leptalea Wahlenb. subsp. *harperi* (Fernald) W. Stone, SJ 16137; LB 28267, 28201
Carex longii Mack., SJ 16361
Carex louisianica Bailey, WRC 17352; SJ 16212; LB 28610, 28157
Carex lupulina Muhl. ex Willd., SJ 17252; LB 28272, 28209, 30563 (SBSC)
Carex lurida Wahlenb., LB 28305
Carex muehlenbergii Schkuhr ex Willd. var. *enervis* Boott, SJ 16043
Carex oxylepis Torr. & Hook., SJ 16153; MM 6337
Carex planispicata R. F. C. Naczi. SJ 16217, 16122
Carex reniformis Small, SJ 16154 5262
Carex retroflexa Muhl. ex Willd., SJ 16284
Carex striatula Michx., LB 30538 (SBSC)
Carex texensis Bailey, SJ 16104; MM 6130
Carex triangularis Boeck., SJ 16118
Carex tribuloides Wahlenb. var. *sangamonensis* Clokey, SJ 16228, 16270; LB 28245
Cyperus croceus Vahl, MM 6555; LB 28718, 28387
Cyperus echinatus Britton , SJ 16400
Cyperus grayioides Mohlenbr. WRC 17705b
Cyperus haspan L., LB 29015, 28729
Cyperus hystricinus Fernald, MM 6756; DR 2364
Cyperus plukenetii Fernald, LB 28671; MM 6720, 6556; DR 2363
Cyperus pseudovegetus Steud., SJ 16365; MM 6698, 6600
Cyperus retroflexus Buckley, LB 28666; MM 6554; DR 2371
Cyperus retrorsus Chapm., LB 28486, 28358
Cyperus strigosus L., LB 28386, 28358
Cyperus virens Michx., SJ 16337; LB 28155
Eleocharis montevidensis Kunth, SJ 16349
Eleocharis obtusa (Willd.) Schult., SJ 16424
Eleocharis tortilis Schult., SJ 16366
Eleocharis tuberculosa (Michx.) Roemer & J.A. Schultes, MM 6245, 6578; LB 28323; SJ 16363
Fuirena squarrosa Michx., MM 6596, 6628
Kyllinga odorata Vahl, LB 28604; MM 6712
Rhynchospora caduca Elliott, SJ 16357
Rhynchospora corniculata (Lam.) A. Gray, MM 6939; LB 28617
Rhynchospora globularis (Chapm.) Small, var. *globularis,* SJ 16382; LB 28677; MM 6530, 6599
Rhynchospora glomerata (L.) Vahl, MM 6735; LB 28430, 28418, 28624
Rhynchospora gracilenta A. Gray, MM 6887; LB 28413; DR 2375
Rhynchospora harveyi W. Boott, LB 28220; SJ 16397
Rhynchospora inexpansa (Michx.) Vahl, LB 28432, 28324
Rhynchospora mixta Britton, LB 28961, 28270, 28340, 28248
Rhynchospora pusilla Chapm. ex M. A. Curt. MM 6574, 6576
Rhynchospora rariflora Elliott, MM 6627; LB 28412, SJ 16266; DR 2365
Rhynchospora scirpoides (Torr.) A. Gray, DR 2376
Scirpus cyperinus L. Kunth, LB 28745, 27848; MM 6540
Scleria ciliata Michx. var. *ciliata,* SJ 16201, 16126; MM 6292; LB 28237
Scleria oligantha Michx., SJ 16280, 16126; MM 6325
Scleria reticularis Michx., MM 6885
Scleria triglomerata Michx., SJ 16423, 16224; LB 28670, 28177

CYRILLACEAE

Cyrilla racemiflora L., LB 28179, 28241; MM 6591; SJ 16368

DENNSTAEDTIACEAE

Pteridium aquilinum (L.) Kuhn, MM 6139; LB 28614

DIOSCOREACEAE

Dioscorea villosa L., LB 27833; SJ 16389

DROSERACEAE

Drosera brevifolia Pursh, MM 6094

Drosera capillaris Poir., MM 6883, 6575; LB 28416; GW 2509

DRYOPTERIDACEAE

Athyrium filix-femina (L.) Roth var. *asplenioides* (Michx.) Farw. SJ 16275; MM 6241

Dryopteris ludoviciana (Kuntze) Small, GW 2600

Onoclea sensibilis L., MM 6345; LB 28246, 27842

Polystichum acrostichoides (Michx.) Schott, SJ 16232; LB 28274, 27808

EBENACEAE

Diospyros virginiana L., MM 6281; LB 28966, 28159

ERICACEAE

Rhododendron canescens (Michx.) Sweet, SJ 16329

Rhododendron viscosum (L.) Torr., SJ 16289; LB 2895, 28279, 27850

Vaccinium arboreum Marshall, SJ 16214; LB 28664, 28145; MM 6291

Vaccinium corymbosum L., LB 28428; 28129; MM 6137; GW 2015

Vaccinium stamineum L., SJ 16066; MM 6320

ERIOCAULACEAE

Eriocaulon texense Koern., MM 6592; SJ 16372

EUPHORBIACEAE

Acalypha gracilens A. Gray, MM 6872, 6757; LB 28953; GW 2768

Acalypha rhomboidea Raf., GW 2603

Chamaesyce cordifolia (Elliott) Small, LB 28675, 28768; MM 6618

Cnidoscolus texanus (Muell.-Arg.) Small, MM 6269; SJ 16428

Croton argyranthemus Michx., MM 6309; LB 28224; GW 2576

Croton capitatus Michx., MM 6718

Croton glandulosus L. var. *septentrionalis* Muell.-Arg. MM 6695, GW 2602; LB 28722, 28370

Croton michauxii G. L. Webster, GW 2687; MM 6619

Euphorbia corollata L., LB 27770; MM 6544; GW 2045

Phyllanthus caroliniensis Walter, LB 28607; GW 2787, 2878

**Phyllanthus urinaria* L., LB 27927; MM 6945

Sebastiania fruticosa (W. Bartram) Fernald, SJ 16152; MM 6327; LB 28187, 27830

Stillingia sylvatica L., SJ 16367; MM 6711

Tragia smallii Shinners, GW 2577

Tragia urticifolia Michx., MM 6306, 6714, 6548; LB 28379

**Triadica sebifera* (L.) Small, SJ 16446

FABACEAE

**Albizia julibrissin* Durazz., SJ 16445; LB 29006, 27771; MM 6524

Baptisia bracteata Muhl. ex Elliott var *laevicaulis* (A. Gray ex Canby) D. Isley, SJ 16106

Baptisia bracteata Muhl. ex Elliott var. *leucophaea* (Nutt.) Kartesz & Gandhi, MM 6132

Baptisia nuttalliana Small, MM 6316, 6133

Centrosema virginianum (L.) Benth., LB 28381

Cercis canadensis L. var. *canadensis*, MM 6150; LB 28681; SJ 28381

Chamaecrista fasciculata (Michx.) Greene, MM 6751; LB 28681

Chamaecrista nictitans (L.) Moench, LB 28711, 28658

Clitoria mariana L., LB 28590, 28757, 28339; MM 6553

Crotalaria sagittalis L., SJ 16220; MM 6693, 6551; LB 28327

Dalea phleoides (Torr. & A. Gray) Shinners, MM 6748

Desmodium ciliare (Muhl. ex Willd.) DC., LB 29032, 28376; GW 2714, 2804

Desmodium glabellum (Michx.) DC., LB 28734, GW 2773 2970

Desmodium laevigatum (Nutt.) DC., LB 29030

Desmodium obtusum DC., LB 28366

Desmodium paniculatum DC., LB 28210; GW 2422

Desmodium rotundifolium DC., LB 28668; GW 2803

Erythrina herbacea L., SJ 16322; MM 6288; LB 28223

Galactia volubilis (L.) Britton, LB 28769; MM 6526, 6552; GW 2578

Gleditsia aquatica Marshall, LB 28725

Indigofera suffruticosa Mill., GW 1742

**Kummerowia striata* Mill., LB 28979, 28925

**Lathyrus hirsutus* L., GW 2011

Lespedeza hirta Elliott, MM 6925; LB 29000

Lespedeza procumbens Michx., LB 28397, 28380, 28231; GW 3440
Lespedeza repens (L.) Barton, LB 28758, 28231a; MM 6702, 6572
Lespedeza stuevei Nutt., LB 28767, 29019; GW 2794
Lespedeza virginica (L.) Britton, LB 28751, 28232; GW 2965
Mimosa hystricina (Small ex Britton & Rose) B. L. Turner, SJ 16258; LB 28216
Rhynchosia difformis (Elliott) DC. LB 28750, 28667,28423; GW 2413
Rhynchosia latifolia Nutt. ex. Torr. & A. Gray, GW 2565, 2733
Rhynchosia reniformis DC., LB 28406, 28235; MM 6270, 6314
Senna marilandica (L.) Link, LB 28642; GW 2049
Senna obtusifolia (L.) Irwin & Barneby, GW 2715
**Senna occidentalis* (L.) Link, GW 2136
+*Sophora affinis* Torr. & A. Gray, GW 2716
Strophostyles umbellata (Muhl. ex Willd.) Britton, LB 28781, 28754
Stylosanthes biflora (L.) Britton, Sterns, Poggenb., MM 5051, 5454
Tephrosia onobrychoides Nutt., MM 6283; LB 28219a; GW 2463
Tephrosia virginiana (L.) Pers., SJ 16391; LB 28661, 28217 MM 6301
**Trifolium campestre* Schreb., MM 6146; SJ 16354
**Trifolium dubium* Sibthrop, LB 27845b
**Trifolium incarnatum* L., SJ 16062; MM 6323
**Trifolium repens* L., SJ 16065
**Vicia sativa* L., MM 6141
Wisteria frutescens (L.) Poir., SJ 16207; LB 28174, 28171, 28175

FAGACEAE

Castanea pumila (L.) Mill. SJ 16314
Fagus grandifolia Ehrh., MM 6101; SJ 16279; LB 27781
Quercus alba L., LB 28125; MM 6602, 6127; SJ 16075
Quercus falcata Michx., MM 6348, 6523; LB 28600; SJ 16304
Quercus hemisphaerica W. Bartram ex Willd., MM 6532; SJ 16110; LB 28777, 28713
Quercus incana W. Bartram, MM 6274, 6568, 6567; SJ 16189
Quercus laurifolia Michx., LB 27844, 27827a, 30560 (SBSC)
Quercus lyrata Walter, LB 28748
Quercus margaretta Ashe ex Small, MM 6318, 6311
Quercus marilandica Muench., MM 6090; SJ 16109; LB 27778, 28665
Quercus michauxii Nutt., LB 28649; MM 6078, 6745; SJ 16084
Quercus nigra L., MM 6077, 6261; SJ 16098; LB 28183
Quercus pagoda Raf., SJ 16169
Quercus phellos L., LB 28117, 27733; MM 6268; SJ 16215
Quercus stellata Wangenh., SJ 16108; LB 29005

GENTIANACEAE

Sabatia angularis (L.) Pursh, CP 1039
Sabatia campestris Nutt. MM 6534; LB 28239

GERANIACEAE

Geranium carolinianum L., SJ 16068

GROSSULARIACEAE

Itea virginica L., SJ 16068; LB 29013, 28133; MM 6243

HALORAGACEAE

**Myriophyllum aquaticum* (Vell.) Verdc., SJ 16292; GW 3345
Proserpinaca palustris L. var. *crebra* Fernald & Grisc. LB 28741
Proserpinaca palustris L. var. *amblyogona* Fernald, LB 28158

HAMAMELIDACEAE

Hamamelis virginiana L., SJ 16307; LB 28176
Liquidambar styraciflua L., SJ 16073, 16441; MM 6120

HIPPOCASTANACEAE

Aesculus pavia L., MM 5234

HYPERICACEAE

Hypericum drummondii (Grev. & Hook.) Torr. & A. Gray, LB 28922, 28765; MM 6613; GW 2793
Hypericum galioides Lam., LB 28422; MM 6587
Hypericum gentianoides (L.) Britton, Sterns, Poggenb., MM 6892, 6621; LB 28988, 28764
Hypericum hypericoides (L.) Crantz, MM 6098
Hypericum mutilum L., LB 28417, 28160; MM 6625
Triadenum walteri (J. G. Gmel.) Gleason, MM 6931, 6953; LB 29016; GW 2821

IRIDACEAE

Alophia drummondii (Graham) R. C. Foster, MM 6516; LB 28392, 28234; SJ 16416

Herbertia lahue (Molina) Goldblatt, MM 6253; SJ 16190
Iris brevicaulis Raf., SJ 16251
Sisyrinchium angustifolium Mill., GW 2530
Sisyrinchium rosulatum E. P. Bicknell, MM 6263; GW 2495
Sisyrinchium sagittiferum E. P. Bicknell, MM 6140; WRC 17353

JUGLANDACEAE
Carya cordiformis (Wangenh.) K. Koch, SJ 16282
Carya glabra (Mill.) Sweet, LB 28623, 28679, 28373; MM 6737
Carya texana Buckley, *LB 28391; MM 6271*
Carya tomentosa (Lam. ex Poir.) Nutt., SJ 16287; LB 27772; GW 2447, 2448
Juglans nigra L., SJ 16393; LB 28609; MM 6349

JUNCACEAE
Juncus acuminatus Michx., LB 30561 (SBSC)
Juncus capitatus Weigel, SJ 16042
Juncus coriaceus Mack., MM 6935, 6528; LB 28632, 28967
Juncus dichotomus Elliott, SJ 16385; MM 6604
Juncus diffusissimus Buckley, SJ 16296
Juncus effusus L., SJ 16138; MM 6254; LB 28207, 27852
Juncus marginatus Rostk., SJ 16346
Juncus repens Michx., MM 6944; LB 27851
Juncus scirpoides Lam., LB 28421; MM 6607
Juncus tenuis Willd., LB 28161; SJ 16405
Juncus trigonocarpus Steud., LB 28161; DR 2366
Juncus validus Coville, SJ 16352, 16406; LB 28328

LAMIACEAE
Hedeoma hispida Pursh, MM 6624
Hyptis alata (Raf.) Shinners, MM 6899
Lycopus rubellus Moench, MM 6941
Lycopus virginicus L., GW 2779, 2044, 2966
Monarda fistulosa L. GW 2020
Monarda punctata L., MM 6717, 6705; LB 28618; GW 2726
**Perilla frutescens* (L.) Britton, LB 28643
Prunella vulgaris L., MM 6305
Pycnanthemum albescens Torr. & A. Gray, LB 28736, 28755; MM 6308, 6707
Pycnanthemum tenuifolium Schrad., SJ 16432; MM 6703
Salvia azurea Michx. var. *grandiflora* Benth., MM 6926; LB 29023
Salvia lyrata L., MM 6117; LB 28645, 27809
Scutellaria cardiophylla Engelm. & A. Gray, LB 28375; MM 6564
Scutellaria elliptica Muhl. ex Sprengel, SJ 16276; LB 28365, 30539 (SBSC), 30453
Scutellaria integrifolia L., LB 28343
Scutellaria parvula Michx., GW 2484; WRC 17333
Stachys tenuifolia Willd., GW 2724
Trichostema dichotomum L., LB 8952; GW 2775
Trichostema setaceum Houtt., MM 6924a; LB 29022

LAURACEAE
Persea borbonia (L.) Spreng., MM 6273, 6087; LB 28126, 28390
Persea palustris (Raf.) Sarg., LB 27847, 28325; SJ 16397
Sassafras albidum (Nutt.) Nees, LB 28639; MM 6272; SJ 16090

LENTIBULARIACEAE
Pinguicula pumila Michx., GW 2510
Utricularia cornuta Michx., LB 30459a (SBSC)
Utricularia gibba L., LB 28717
Utricularia inflata Walter, PR s.n.
Utricularia juncea Vahl, MM 6585
Utricularia subulata L., GW 2487

LILIACEAE
Allium canadense L. var. *canadense*, MM 6282; GW 2537
Allium canadense L. var. *mobilense* (Regel) Ownbey, SJ 16197
Hypoxis curtissii Rose, MM 6343; GW 2522; LB 28175a; SJ 16235
Nothoscordum bivalve (L.) Britton, MM 6095

LINACEAE
Linum medium (Planch.) Britton var. *texanum* (Planch.) Fernald, MM 6533; LB 28424, 28218; GW 2574
Linum striatum Walter, GW 2598, 2719; MM 6519

LOGANIACEAE
Gelsemium sempervirens (L.) Aiton f., MM 6113 SEWP 2005
Mitreola petiolata (J.F. Gmel.) Torr. & A. Gray, LB 29017, 28739; GW 2780
Mitreola sessilifolia (J.F. Gmel.) G. Don, LB 28431; MM 6626; GW 2695

LYCOPODIACEAE
Lycopodiella appressa (Chapm.) Cranfill, MM 6890, 6579

Pseudolycopodiella caroliniana (L.) Holub var. *caroliniana*, MM 6582; GW 2712

LYGODIACEAE

**Lygodium japonicum* (Thunb. ex Murray) Sw., MM 6317; SJ 16211; WRC 10845

LYTHRACEAE

**Cuphea carthagenensis* (Jacq.) J.F. Macbr., MM 6298, 6741; LB 28963

**Cuphea glutinosa* Cham.& Schlecht., MM 6266; LB 28393; GW 2512

Rotala ramosior (L.) Koehne, GW 2782

MAGNOLIACEAE

Magnolia grandiflora L., LB 27818,28196; MM 6149; SJ 16070

Magnolia virginiana L., MM 6248; LB 27813; SJ 16371

MALVACEAE

Malvaviscus arboreus Dill.ex.Cav.var.*drummondii* (Torr. ex A. Gray) Schery, LB 28345; MM 6719

Sida rhombifolia L., MM 6752; LB 28637

Sida spinosa L., GW 2725

MAYACACEAE

Mayaca fluviatilis Aubl., GW 2507, 2788

MELASTOMATACEAE

Rhexia mariana L., MM 6608; LB 28330; GW 2597, 2969

Rhexia virginica L., LB 28728; MM 6733

MELIACEAE

**Melia azedarach* L., LB 28964

MENISPERMACEAE

Cocculus carolinus (L.) DC., LB 28203

MOLLUGINACEAE

Mollugo verticillata L., MM 6606; SJ 16377

MONOTROPACEAE

Monotropa uniflora L., LB 28372

MORACEAE

Morus rubra L., MM 6123; LB 28776; SJ16438; GW 3335

MYRICACEAE

Morella caroliniensis (Mill.) Small, MM 6237, LB 28956, 28784, 28182

Morella cerifera (L.) Small, MM 6340; LB 28130, 28247; GW 2707

NYMPHAEACEAE

Nuphar lutea (L.) Sm. subsp. *advena* (Aiton) Kartesz & Gandhi, LB 26168

OLEACEAE

Chionanthus virginicus L., MM 6118; LB 28137, 28354; SJ 16089

Forestiera ligustrina (Michx.) Poir., GW 1944, 2421, 2515; LB 27817

Fraxinus americana L., MM 6319; GW 2708; LB 28106; SJ 16365

Fraxinus caroliniana Mill., SJ 16203; LB 30565 (SBSC)

Fraxinus pennsylvanica Marshall., MM 6076

**Ligustrum sinense* Lour., LB 28945; SJ 16251

ONAGRACEAE

Ludwigia alternifolia L., LB 28331; GW 2799

Ludwigia decurrens Walter, GW 2798; LB 28724; MM 6949

Ludwigia glandulosa Walter, GW 2720, 2967; LB 28744

Ludwigia hirtella Raf.; LB 28328; MM 6585, 6734

Ludwigia leptocarpa (Nutt.) Hara, GW 2968

Ludwigia linearis Walter, MM 6897

Ludwigia pilosa Walter, LB 30560 (SBSC)

Oenothera laciniata Hill, GW 2492

Oenothera linifolia Nutt., MM 6305

Oenothera speciosa Nutt., MM 6260; SJ 16344

OPHIOGLOSSACEAE

Botrychium biternatum (Sav.) Underwood, MM 6910; LB 27831

Botrychium virginianum (L.) Sw., MM 6331, 6147; GW 1945

ORCHIDACEAE

Corallorhiza wisteriana Conrad, SEWP 2007

Listera australis Lindl., SEWP 2003

Platanthera clavellata (Michx.) Luer, LB 28268; GW 2563

Platanthera cristata (Michx.) Lindl., GW 2701

Spiranthes cernua (L.) L. C. Rich., MM 6952; GW 3449

Spiranthes lacera (Raf.) Raf. var. *gracilis* (Bigelow) Luer, MM 6620

Spiranthes praecox (Walter) S. Watson, SJ 16259

Spiranthes tuberosa Raf., LB 28382; MM 6573

OROBANCHACEAE

Epifagus virginiana (L.) W. Bart., LB 28271

OSMUNDACEAE

Osmunda cinnamonea L., MM 6242; LB 28190

Osmunda regalis L. var *spectabilis* (Willd.) A. Gray, MM 6259; LB 28123, 28206, 27855

OXALIDACEAE

Oxalis corniculata L. var. *wrightii* (A. Gray) B. L. Turner, MM 6096

**Oxalis debilis* Kunth var. *corymbosa* (DC.) Lourteig, SJ 16231

Oxalis lyonii Pursh, (T) MM 6135; WRC 17337

PASSIFLORACEAE

Passiflora lutea L., MM 6293, 6742; LB 28939, 28338

PHYTOLACCACEAE

Phytolacca americana L., LB 28140

PINACEAE

Pinus echinata Mill., MM 6893, 6082; LB 28949; SJ 16288

Pinus palustris Mill., MM 6070; SJ 16311

Pinus taeda L., MM 6083; SJ 16257

PLANTAGINACEAE

Plantago aristata Michx., SJ 16295; LB 28236; MM 6623

PLATANACEAE

Platanus occidentalis L., MM 6246; SJ 16434; LB 27816; GW 2046

POACEAE

Agrostis elliottiana J.A. Schultes, GW 2501

Agrostis hyemalis (Walter) Britton, Sterns, Poggenb., MM 6321

**Aira elegans* Willd. ex Kunth, MM 6235; LB 28212

Andropogon gerardii Vitman, LB 29033, 28999

Andropogon glomeratus (Walter) Britton, Sterns, Poggenb. LB 28965; GW 2784

Andropogon gyrans Ashe var. *gyrans*, WRC 17339

Andropogon ternarius Michx., MM 6874, 6916; GW 2807; LB 28982

Andropogon virginicus L. var. *virginicus*, LB 29027, 28997, 28941, 28936

Aristida lanosa Muhl. ex Willd., MM 6927; LB 29002; WRC 10829; DR 2367

Aristida longispica Poir. var. *geniculata* (Raf.) Fernald, MM 6904

Aristida longispica Poir. var. *longispica*, LB 28926; GW 2789, 2816

Aristida oligantha Michx. GW 2791

Aristida purpurascens Poir. var. *purpurascens*, MM 6871; LB 29004, 28991, 28931

Arundinaria gigantea (Walter) Muhl., MM 6072; LB 28650, SJ 16120; SEWP 2001

Axonopus fissifolius (Raddi) Kuhlm., LB 28359, 28611; GW 2705

**Briza minor* L., MM 6079; GW 2611

**Bromus japonicus* Thunb. ex Murr., SJ 16359

Cenchrus spinifex Cav., LB 28363; MM 6615; GW 2704

Chasmanthium latifolium (Michx.) Yates, SJ 16403; LB 28350, 28151; MM 6743

Chasmanthium laxum (L.) Yates var. *laxum*, LB 28730

Chasmanthium laxum (L.) Yates var. *sessiliflorum* (Poir.) Wipff & S. Jones, MM 6722; LB 28714, 28348

Dichanthelium aciculare (Desv. ex Poir.) Gould & Clark SJ 16060, 16107; LB 28238

Dichanthelium aciculare (Desv. ex Poir.) Gould & Clark subsp. *angustifolium* (Elliott) Freckman & Lelong, LB 28367

Dichanthelium acuminatum (Sw.) Gould & Clark var. *acuminatum*, SJ 16427; LB 28335

Dichanthelium boscii (Poir.) Gould & Clark, LB 28273, 28663, 28351, 28149

Dichanthelium commutatum (Schultes) Gould subsp. *commutatum*, MM 6239; SJ 16064, 16313; LB 28716, 30460b (SBSC)

Dichanthelium commutatum (Schultes) Gould subsp. *equilateral* (Scribn.) Freckman & Lelong, LB 28589

Dichanthelium dichotomum (L.) Gould var. *dichotomum*, MM 6299; LB 28975, 28628; SJ 16171

Dichanthelium dichotomum (L.) Gould subsp. *microcarpon* (Elliott) Freckman & Lelong, LB 28166, 28164

Dichanthelium ensifolium (Baldw. ex Elliott) Gould subsp. *ensifolium*, LB 29038; SJ 16308

Dichanthelium laxiflorum (Lam.) Gould, LB 27788; WRC 17342

Dichanthelium oligosanthes (Schult.) Gould, var. *oligosanthes*, SJ 16184

Dichanthelium oligosanthes (Schult.) Gould var. *scribnerianum* (Nash) Gould, LB 28369

Dichanthelium oligosanthes (Schult.) Gould, WRC 17340

Dichanthelium ovale (Elliott) Gould & C.A. Clark

subsp. *villosissimum* (Nash) Freckman & Lelong, SJ 16263, 16195; MM 6277; WRC 17341
Dichanthelium polyanthes (Schult.) Mohlenbr., LB 28384, 30567 (SBSC), 30573 (SBSC); SJ 16404
Dichanthelium ravenelii (Scribner & Merr.) Gould & Clark, MM 6290; SJ 16435
Dichanthelium scoparium (Lam.) Gould, SJ 16407; LB 28405; MM 6612
Dichanthelium sphaerocarpon (Elliott) Gould, MM 6298, 6563; SJ 16265 LB 28630
Dichanthelium wrightianum (Scribn.) Freckmann, LB 28433; MM 6583
Digitaria ciliaris (Retz.) Koel., LB 28933, 28712
Digitaria cognata (J.A. Schultes) Pilger var. *cognata*, GW 2815
Digitaria filiformis (L.) Koel. var. *filiformis* GW 2806
Digitaria filiformis (L.) Koel. var *villosa* (Walter) Fernald, MM 6876; LB 29026; GW 2418
**Digitaria violascens* Link, LB 29009
Elymus virginicus L., LB 28208, 28732; MM 6535; SJ 16444
Eragrostis elliottii S. Watson, GW 2812
Eragrostis hypnoides (Lam.) Britton, Sterns, Poggenb., GW 2719b
Eragrostis intermedia (Lam.) Britton, Sterns, Poggenb., LB 28944
Eragrostis refracta (Muhl.) Scribn., LB 28989
Eragrostis secundiflora (J. Presl) subsp. *oxylepis* (Torr.) S.D. Koch, MM 6696; LB 28774; GW 2797
Eragrostis spectabilis (Pursh) Steud., MM 6915, 6869, 6902; LB 28983
Eustachys petraea (Sw.) Desv., MM 6903
Gymnopogon ambiguus (Michx.) Britton, Sterns & Poggenb., MM 6865; GW 2808; DR 2368
Leersia virginica Willd., LB 28971, 28627
**Lolium perenne* L., MM 6322; SJ 16350
Melica mutica Walter, MM 6108; LB 28173, 27832
Oplismenus hirtellus (L.) Beauv., LB 28648; MM 6938
Panicum anceps Michx., MM 5757, 5646; LB 29008, 28974
Panicum brachyanthum Steud., MM 6912; LB 68980, 68929; WRC 10832
Panicum gymnocarpon Elliott, LB 28973, 28740
Panicum rigidulum Bosc ex Nees, LB 28747
Panicum verrucosum Muhl., MM 6881, 6950; LB 29037, 29011
**Paspalum notatum* Fluegge, MM 6875, 6537; LB 28603; GW 2585a
Paspalum plicatulum Michx., MM 6864, 6731; LB 28199; SJ 16356
Paspalum praecox Walter, MM 3933, 3719, 3937
Paspalum setaceum Michx., GW 2419; LB 2403, 28928; MM 6724
**Paspalum urvillei* Steud., MM 6895, 6541; LB 28221, 29010
Phalaris angusta Nees ex Trin., SJ 16255
Piptochaetium avenaceum (L.) Parodi, MM 6329; SJ 16378
**Poa annua* L., MM 6142; GW 2497, 2498
Poa autumnalis Muhl. ex Elliott, LB 27829
Saccharum giganteum (Walter) Pers., MM 6880
Schizachyrium scoparium (Michx.) Nash var. *divergens* (Hack.) Gould, LB 28998; GW 2814
Setaria parviflora (Poir.) Kerguelen, LB 28361
Sorghastrum elliottii (Mohr) Nash, MM 6919
Sphenopholis filiformis (Chapm.) Scribn., WRC 17336
Sphenopholis intermedia (Rydb.) Rydb., SJ 16229
Sphenopholis obtusata (Michx.) Scribn., MM 6300
Sporobolus clandestinus (Biehler) A.S. Hitchc., MM 6904; LB 29003, 28994; GW 2813
Sporobolus indicus (L.) R. Br., LB 28930
Sporobolus junceus (Beauv.) Kunth, LB 28993; MM 6920; DR 2369
Steinchisma hians (Elliott) Nash, SJ 16298
Tridens flavus (L.) Hitchc. var. *chapmanii* (Small) Shinners, WRC 10826
Tridens flavus (L.) Hitchc. var. *flavus*, LB 28634; GW 2426, 2819, 2783
Tridens strictus (Nutt.) Nash, LB 28904

POLEMONIACEAE

Phlox nivalis Lodd. ex Sweet subsp. *texensis* Lundell, MM s.n.; WRC 17332

POLYGALACEAE

Polygala mariana Mill., LB 28215; SJ 16206
Polygala polygama Walter, MM 6296; LB 28116

POLYGONACEAE

Brunnichia ovata (Walter) Shinners, MM 6951; LB 28138
Polygonum punctatum Elliott, MM 6930; LB 28656; GW 2883, 2778a
Polygonum virginianum L., LB 28656a

POLYPODIACEAE

Pleopeltis polypodioides Andrews & Windham subsp. *michauxiana* (Weatherby) Andrews & Windham, LB 28407, 27795

POTAMOGETONACEAE

Potamogeton diversifolius Raf., SJ 16273; LB 28682; GW 2506
Potamogeton pulcher Tuckerman, GW 2561

PRIMULACEAE

**Anagallis arvensis* L., MM 6089
Anagallis minima (L.) Krause, LB 27777
Samolus valerandi L. subsp. *parviflorus* (Raf.) Hultén, LB 29040; SJ 16241

RANUNCULACEAE

Clematis reticulata Walter, GW 2734; MM 6610
Ranunculus hispidus Michx. var. *nitidus* (Chapm.) T. Duncan, LB 27841; GW 2734
**Ranunculus parviflorus* L., GW 2517
Ranunculus pusillus Poir., GW 2480
+*Ranunculus recurvatus* Poir., GW 3351

RHAMNACEAE

Berchemia scandens (Hill) K. Koch, MM 6103; LB 27861;SJ 16159
Rhamnus caroliniana Walter, MM 6122; LB 28633, 27799, 30572 (SBSC)

ROSACEAE

Agrimonia microcarpa Wallr., GW 2769, 3425; MM 6721
Agrimonia rostellata Wallr., LB 28732; MM 6334
Crataegus marshallii Egglest., MM 6726; LB 28970, 27825a; SJ 16074
Crataegus opaca Hook. & Arn., SJ 16078
Crataegus spathulata Michx., SJ 16096; LB 28644, 27798; GW 2461
Crataegus uniflora Muench., GW 2014
Crataegus viridis L., GW 1947a
Prunus caroliniana (Mill.) Aiton, LB 28951
Prunus gracilis Engelman & A. Gray, MM 6284; LB 27785
Prunus serotina Ehrh., MM 6119; LB 28785, 28269; SJ 16067
Prunus umbellata Elliott, LB 27800; SJ 16172
Rubus argutus Link, SJ 16155; LB 28788; GW 2706, 2457
Rubus trivialis Michx., MM 6116

RUBIACEAE

Cephalanthus occidentalis L., MM 6932, 6593
Diodia teres Walter, MM 6694; LB 2840
Galium pilosum Aiton, GW 2573; MM 6326
Galium tinctorium (L.) Scop., LB 27806; GW 2483
Galium triflorum Michx., SJ 16283; LB 28789
Galium uniflorum Michx., SJ 16278; LB 30460a (SBSC)
Houstonia micrantha (Shinners) Terrell, WRC 17334
Houstonia pusilla Schoepf, MM 6112
Mitchella repens L., MM 6247, 6189; LB 27803; SJ 16162
Oldenlandia uniflora L., GW 2713, 2790
Pentodon pentandrus (K. Schum.) Vatke, LB 28608; DR 2374
**Richardia scabra* L., LB 28924
**Sherardia arvensis* L., MM 6136
Stenaria nigricans (Lam.) Terrell, LB 28368, 28222; MM 6539

RUTACEAE

**Poncirus trifoliata* (L.) Raf., SJ 16246; LB 28652
Zanthoxylum clava-herculis L., LB 28185

SALICACEAE

Salix nigra Marshall., SJ 16142

SAPOTACEAE

Sideroxylum lanuginosum Michx. subsp. *oblongifolium* (Nutt.) T.D. Pennington, SJ 16306

SARRACENIACEAE

Sarracenia alata Wood, MM 6589

SAURURACEAE

Saururus cernuus L., LB 28620, 28142a; MM 6943

SAXIFRAGACEAE

Lepuropetalon spathulatum Elliott, LB 27768

SCROPHULARIACEAE

Agalinis fasciculata (Elliott) Raf., LB 28948, 28923
+*Agalinis filifolia* (Nutt.) Raf., MM 6921, 6922, 6901
Agalinis purpurea (L.) Pennell, LB 29029; GW 2879
Aureolaria flava (L.) Farw. var *macrantha* Pennell, MM 5639
Aureolaria grandiflora (Benth.) Pennell, MM 6751; LB 28591; GW 2736
Aureolaria pectinata (Nutt.) Pennell, GW 2880
Bacopa caroliniana (Walter) Robins. LB 30562 (SBSC)
Gratiola neglecta Torr., GW 2526
Gratiola pilosa Michx., GW 2696; LB 29036; MM 6581
Gratiola virginiana L., GW 2485, 2525, 2604
Lindernia dubia (L.) Pennell, SJ 16146; LB 28720; GW 2605
Mecardonia acuminata (Walter) Small, GW 2781; LB 29028, 28230

Mecardonia procumbens (Mill.) Small, GW 809
Micranthemum umbrosum (J. G. Gmel.) Blake, SJ 16269; LB 28592
Penstemon laxiflorus Pennell, MM 6307, 6088; SJ 16077; LB 28227
Scoparia dulcis L., MM 6692; LB 28357, 28225

SELAGINELLACEAE
Selaginella apoda (L.) Spring, MM 6255; GW 2508; SJ 16419

SMILACACEAE
Smilax bona-nox L., MM 6691
Smilax glauca Walter, LB 28977, 28119
Smilax laurifolia L., MM 6250, 6736; LB 28193; SJ 16272
Smilax pumila Walter, MM 6086; SJ 16161
Smilax rotundifolia L., MM 6238; SJ 16436; LB 27779
Smilax smallii Morong, MM 6240; LB 28938, 28233; SJ 16158
Smilax tamnoides L., SJ 16202

SOLANACEAE
Physalis heterophylla Nees, MM 6286; GW 2801
Physalis pubescens L., GW 2599
Physalis pumila Nutt., MM 5369, 5404; GW 2660
Solanum carolinense L., MM 6723; LB 28337
**Solanum capsicastrum* Link ex Schauer, GW 2047
Solanum ptycanthum Dunal, MM 6937; SJ 16248

SPARGANIACEAE
Sparganium americanum Nutt., SJ 16293; LB 30564 (SBSC)

STYRACACEAE
Halesia diptera Ellis, SJ 16412; LB 27825
Styrax grandifolius Aiton, LB 28128, 28124, 28127

SYMPLOCACEAE
Symplocos tinctoria (L.) L. Her, SJ 16318; LB 28783, 28277

THELYPTERIDACEAE
Thelypteris kunthii (Desv.) Morton, MM 6339; SJ 16227; LB 26244, 26244

TILIACEAE
Tilia americana L. var. *caroliniana* (Mill.) Castigl., LB 27828; GW 2012, 2048

ULMACEAE
Celtis laevigata Willd., GW 2513b, 2514c
Celtis tenuifolia Nutt., MM 6522: LB 30534 (SBSC), 30560 (SBSC)
Planera aquatica J.F. Gmel., LB 28180; SJ 16204,6414; GW 2042
Ulmus alata Michx., MM 6706, 6092; GW 2415; SJ 16439
Ulmus americana L., SJ 16132, SJ 16140; LB 28211; GW 2425

URTICACEAE
Boehmeria cylindrica (L.) Sw., LB 28344, 28136; MM 6744

VALERIANACEAE
Valerianella radiata (L.) Dufr., MM 6333

VERBENACEAE
Callicarpa americana L., SJ 16442; LB 28347; MM 6557, 6097
Glandularia canadensis (L.) Nutt., MM 6115; LB 28408
Phyla nodiflora (L.) Greene, SJ 16431
**Verbena brasiliensis* Vell., SJ 6908
Verbena halei Small, MM 6308; LB 28236a; GW 2689
**Verbena rigida* Spreng., MM 6542
**Vitex agnus-castus* L., MM 6542

VIOLACEAE
Viola lanceolata L., LB 27859
Viola palmata L., MM 6129; LB 27812; GW 2519, 2542
Viola pedata L., MM 6138; SJ 16092
Viola primulifolia L., SJ 16134; LB 29014; MM 6252; SEWP 2004
Viola sororia Willd. var *missouriensis* (Greene) McKinney, LB 28135, 27819; GW 1941, 2443
Viola villosa Walter, MM 6109; LB 27787; GW 2481, 2531

VITACEAE
Ampelopsis arborea (L.) Koehne, MM 6728, 6728; LB 228204
Parthenocissus quinquefolia (L.) Planch., MM 6126; SJ 16094
Vitis aestivalis Michx., GW 2580; MM 6558, 6287; SJ 16274
Vitis cinerea (Engelm) Millard. var. *cinerea*, LB 28976, 28605, 28132
Vitis rotundifolia Michx., MM 6124; LB 28120; SJ 16223

XYRIDACEAE
Xyris ambigua Bey. ex Kunth, LB 28715
Xyris baldwiniana Schult., MM 6580; GW 2711; LB 30459

Xyris difformis Chapm. var. *curtissii* (Malme) Kral, LB 28425; MM 6732

Xyris difformis Chapm. var. *difformis*, GW 2710
Xyris jupicai L. C. Rich., MM 6888, 6700

Notes

Agalinis filifolia.—We are following Wunderlin (1998) in merging *A. pulchella* with *A. filifolia.*

Cerastium pumilum.—Turner et al (2003) mapped this exotic species in six northeastern Texas counties with Kaufman County the most southern. Our Polk County record and another one from San Jacinto County (both at SBSC) are the most southern Texas collections known to us.

Croptilon hookerianum.—The Polk County collection is the first for the pineywoods region of east Texas. The most eastern collection in Turner et al. (2003) is from Fayette County. It is distinguished from *C. divaricatum* and *C. rigidifolium* (the only other *Croptilon* taxa in Texas) by the lack of non-glandular trichomes on the distal portions of the stems.

Diaperia candida.—In the *Flora of North America* Asteraceae volumes (ined.), our *Evax* taxa are treated in the genus *Diaperia.*

Loeflingia squarrosa.—This western taxa appears to be new to Polk County (Turner et al. 2003). This, *Prunus gracilis,* and *Croptilon hookerianum* are the only strictly western species found on the Big Sandy Creek Unit. These are characteristic species of xeric sandylands.

Minuartia muscorum.—For the curious nomenclatural history of this taxon see Rabeler (1992).

Phlox nivalis subsp. **texensis.**—This endemic to southeast Texas and a federally and state listed endangered species (Poole & Riskind 1987; Texas Parks and Wildlife 2004), was located on the Big Sandy Creek Unit during the study. The species has been planted in several locations in the unit by the U.S. Park Service, but the population located during this study was a naturally occurring one which had been known for some years.

Ranunculus recurvatus.—Our Polk County collection is one of only four counties mapped in Turner et al. (2003).

Silene subciliata.—In addition to *Phlox nivalis* ssp. *texensis, Silene subcilata* is the only other Texas rare species found on the Big Sandy Creek Unit. This West Gulf Coastal Plain endemic is rare in both Texas and Louisiana, but is not federally listed. In addition to these two rare West Gulf Coastal Plain endemics, the Big Sandy Creek Unit has several other West Gulf Coastal Plain endemics (MacRoberts et al. 2002a). These are *Baptisia bracteata* var. *leucophaea, Baptisia nuttalliana, Berlandiera pumila* var. *scabrella, Dalea phleoides* var. *phleoides, Echinacea pallida* var. *sanguinea, Hymenopappus artemisiifolius* var. *artemisiifolius, Lobelia puberula, Mimosa hystricina, Oligoneuron nitidum, Panicum brachyanthum, Scutellaria cardiophylla, Sisyrinchium sagittiferum, Solidago ludoviciana, Tradescantia reverchonii,* and *Vernonia texana.*

Sophora affinis.—Our Polk County collection is one of only three specimens known to us from the pineywoods region in east Texas. The other two collections are from the Trinity River bottomlands in Liberty County.

DISCUSSION

There are 126 families and 358 genera for the 693 taxa (648 native) on the Big Sandy Creek Unit list. Also, 50.9 % of all taxa belong to eight families; they are Poaceae (88 taxa), Asteraceae (85 taxa), Cyperaceae (69 taxa), Fabaceae (46 taxa), Lamiaceae (19 taxa), Euphorbiaceae (16 taxa), Scrophulariaceae (16 taxa), and Fagaceae (15 taxa). The largest genera are *Carex* (35 taxa), *Dichanthelium* (19 taxa), *Quercus* (13 taxa) *Cyperus* (11 taxa), and *Rhynchospora* (11 taxa).

We compared our list of taxa for Big Sandy Creek Unit with the Polk County taxa reported by Turner et al. (2003) in their *Atlas of the vascular plants of Texas* and found that only 70 percent of our taxa are mapped for Polk County in that source. This is not surprising considering that until recently little focused collecting has been undertaken in the Big Thicket region and indicates that basic floristic collecting and documentation in the Big Thicket region are still needed.

Thus, while it is the case that our list is incomplete and that a few taxa may no longer exist on the unit, most taxa that have grown in the Big Sandy Creek Unit during the past quarter century have been collected (probably 85+ percent). We estimate that the Big Sandy Creek Unit has about 660 to 750 native species/taxa.

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THE NORTH-SOUTH TRANSITION OF FLORA ACROSS ARKANSAS: A PRELIMINARY PHYTOGEOGRAPHICAL ANALYSIS

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ABSTRACT

Biogeographers have divided Arkansas into physiogeographic provinces and ecoregions. Using quantitative methods, we examined the north-south floristic transition across Arkansas to see if phytogeographic regions are detectable by abrupt changes in the flora. We found only gradual change even though there are abrupt and major physiographical discontinuities.

RESUMEN

Los biogeógrafos han dividido Arkansas en provincias fisiogeográficas y ecorregiones. Usando métodos cuantitativos, examinamos las transiciones norte-sur a través de Arkansas para ver si las regiones fitogeográficas son detectables por cambios abruptos en la flora. Hemos encontrado sólo cambio gradual aunque hay discontinuidades fisiográficas abruptas y mayores.

INTRODUCTION

Virtually all physiogeographic and ecoregional mappers treat the Interior Highlands of Arkansas, Illinois, Kansas, Missouri, and Oklahoma as being distinct from surrounding areas. While most appear to agree on a physiogeographic map, they present conflicting interpretations of the biotic provinces and ecoregions (e.g., Dice 1943; Braun 1950; Gleason & Cronquist 1964; Kuchler 1964; Foti 1974; Pell 1983; Omernik 1986; Takhtajan 1986; Thorne 1993; Bailey et al. 1994; Keys et al. 1995; Weakley et al. 1998; Foti & Bukenhofer 1998; Ricketts 1999). For example, Dice (1943), Takhtajan (1986), and Thorne (1993) consider the Interior Highlands and Gulf Coastal Plain to be different provinces, Bailey et al. (1994) and Keys et al. (1995) break the Interior Highlands into two provinces, Omernik (1986) divides the area into six ecoregions, and Weakley et al. (1998) divide it into four ecoregions.

While it is unquestionably the case that the Ouachita Mountains and the Ozark Plateau are physiogeographically distinct from surrounding areas, notably the West Gulf Coastal Plain to the south, it is not so certain that the area is particularly distinct floristically. Zollner et al. (2005:1788), speaking of the In-

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terior Highlands in general, question its uniqueness: "for all of its physiographic uniqueness, including age, long-term isolation from its moiety—the Appalachian region—, and its reputation as a 'well-known refugium' (Meyer 1997:364) [the Interior Highlands] shows surprisingly little floristic uniquity from surrounding regions." This was also recognized years ago by Palmer (1921) when he pointed out that about 90 percent of the woody flora of the Ozark region also occurs in the Gulf Coastal Plain.

This point was brought home to us forcefully when we conducted a floristic inventory of the Ouachita Mountains Biological Station in Polk County, Arkansas (MacRoberts et al. 2005). Having extensive experience with the flora of the West Gulf Coastal Plain, but none with the Ouachita Mountains, we expected, since the physiogeography was so different and since biogeographers have separated the Interior Highlands from the Coastal Plain, that the two areas would be quite floristically distinct. Surprisingly they are not. The flora of the Ouachita Mountains Biological Station presented some species unknown to us, but not many.

In a previous paper, we documented the east-west floristic transition across central Texas in which the eastern flora precipitously drops out and is replaced by a western flora and vice versa (MacRoberts & MacRoberts 2003). In this study, using similar methods we examine the north-south floristic transition across Arkansas, i.e., from the West Gulf Coastal Plain in the south into the Interior Highlands in the north (Fig. 1). Western Louisiana and southern Arkansas are physiographically the Gulf Coastal Plain (Fenneman 1938; Brouillet & Whetstone 1993) and the Atlantic and Gulf Coastal Plain floristic province (Takhtajan 1986; Thorne 1993). The Interior Highlands, on the other hand, are part of the Ozark and Ouachita physiographic region (Fenneman 1938; Brouillet & Whetstone 1993) and the Appalachian floristic province (Takhtajan 1986; Thorne 1993).

The purpose of this paper is to provide data on 1) how different floristically the Interior Highlands is from the West Gulf Coastal Plain, 2) the effect of the physiogeographic differences on the north-south floristic transition of flora from the Coastal Plain into the Interior Highlands, and 3) the floristic relationship between the Interior Highlands and the regions that surround it.

STUDY SITES

The Interior Highlands and the Gulf Coastal Plain have been described in numerous publications (Fenneman 1938; Foti 1974; Pell 1983; Bryant et al. 1993; Skeen et al. 1993; Dale & Ware 1999; Delcourt & Delcourt 2000) and will not be redescribed here except to say that the former region consists of moderate elevation mountains of Paleozoic sedimentary rock with numerous swift clear streams and rivers and both deciduous and pine-hardwood forests; the latter region consists of low to gently rolling topography of Cretaceous and Tertiary silts and clays char-

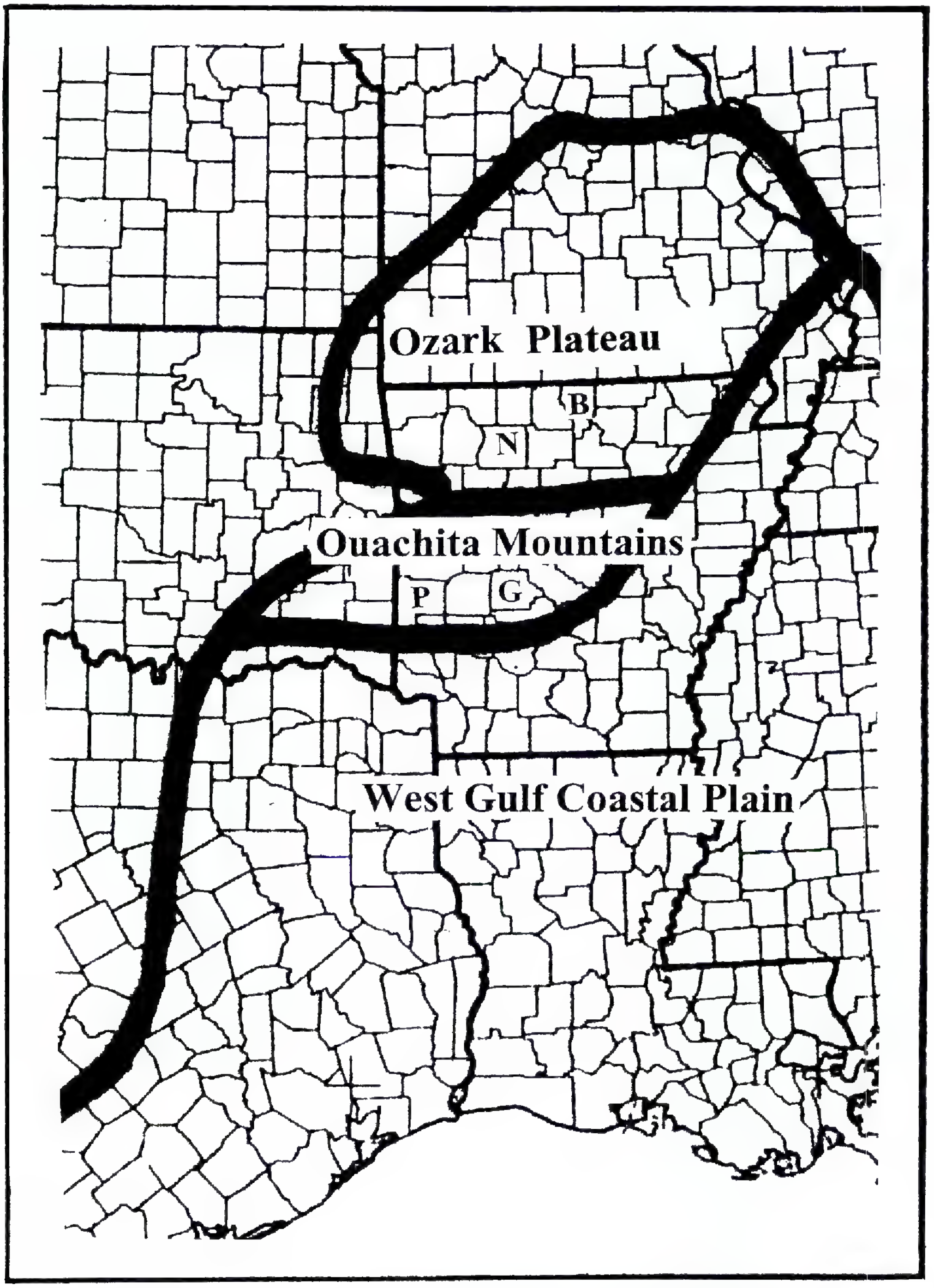


FIG. 1. Location of Interior Highlands and Gulf Coastal Plain showing location of Ouachita Mountins and Ozark Plateau and Baxter (B), Garland (G), Newton (N), and Polk (P) counties.

acterized by forests of pine and hardwoods, with swamps, and sluggish muddy streams and rivers, and oxbow lakes. Precipitation is about the same in both areas, with temperatures slightly cooler in the Interior Highlands.

METHODS

1) As we pointed out in the introduction, we have recently conducted a floristic survey of the 211 hectare Ouachita Mountains Biological Station in Polk County, Arkansas (MacRoberts et al. 2005). It is located 174 km north of Louisiana in the Ouachita Mountains and has an elevation range of between 395 and 622 meters. It is dominated by pine-hardwood forests on shale, chert, novaculite, siltstone, and sandstone. It could not be more different edaphically and topographically from the West Gulf Coastal Plain. We have documented 315 native species on the station. We compared this list to floristic lists for Louisiana (Thomas & Allen 1993–1998; Kartesz & Meacham 1999) to determine the percentage of species in common. While the Ouachita Mountains Biological Station is a very small area given the size and diversity of the Ouachita Mountains, it provided a first comparison of the flora between the West Gulf Coastal Plain and the Ouachita Mountains.

2) In order to obtain a more detailed understanding of the possible effect of the Interior Highlands on plant distribution, using the Thomas and Allen (1993–1998) atlas we randomly selected 254 native species occurring in northern Louisiana (north of T1N) that also occur in Arkansas (Smith 1988, 1994). Using Kartesz and Meacham (1999), we determined how many of these occur in Missouri, approximately 380 km to the north. The sample size is only about 10 percent of the native species but sufficient to compare the flora between the regions.

3) As an independent test of Method 2, using Hyatt (1993) we determined the percentage of native species occurring in Baxter County, Arkansas, on the Missouri border in the Ozark Plateau, that also occur in the Gulf Coastal Plain of Texas and Louisiana (Thomas & Allen 1993–1998; Kartesz & Meacham 1999; Turner et al. 2003). Naturally, some of the species in this sample are the same as those in Method 2.

4) Using the data in Method 2, we plotted the Arkansas county distribution of the 254 native species. Because all counties are not collected equally (e.g., Jackson County has 275 reported taxa while Washington County has 1,301 reported taxa), we expressed the results as percentages; that is, we divided the number of species in our sample reported for each county by the total species reported for each county. Thus, of the 254 species in the sample, 99 are reported for Miller County, and Smith (1988) reports 544 species for Miller County (99/544 = 18%).

5) Having found that Method 4 did not reveal sharp distributional discontinuities in the flora across Arkansas (see "Results"), using Kartesz and

Meacham (1999) we surveyed the entire flora of North America and found all of the native species that were reported to occur in Missouri and Arkansas (but not in Louisiana) and in Louisiana and Arkansas (but not in Missouri) irrespective of where else they occurred. Using Smith (1988), we then plotted these species by Arkansas counties according to whether they were Missouri/Arkansas species or Louisiana/Arkansas species (i.e., coming from the north or the south). Our sample consisted of 499 species: 272 Missouri/Arkansas and 227 Louisiana/Arkansas. Our numerical procedure was the same as in Method 4. Our hope was to magnify the curve by eliminating species that occurred in all three states.

6) In order to determine the overall North American floristic association of the Interior Highlands, using Smith (1988) we randomly selected 296 native species from Garland County, Arkansas, which is entirely within the Ouachita Mountain region, and 293 native species from Newton County, Arkansas, which is entirely within the Ozark Plateau region (both counties being well collected) and, using Kartesz and Meacham (1999), plotted their state/regional occurrence expressed as percentage of species in common.

All of these measures are of presence/absence, not abundance. The data necessary to investigate abundance are not yet available on a large scale. Thus, we recognize that some taxa may be widely distributed across the region while others may not. Also, while we recognize the limitation of the main data sources for this paper, we have made every effort to adjust to those limitations. But since the study is a preliminary analysis, it can absorb some error without compromising the general conclusions. The paper provides a problem and an analysis that should be followed up by a more extensive sample of species and more points along the continuum.

RESULTS

1) Of the 315 species on our Ouachita Mountain Biological Station list, 287 or 91% occur in Louisiana entirely within the West Gulf Coastal Plain.

2) Of the 254 species in our north Louisiana sample, 209 or 82% reached Missouri and 45 or 18% stopped in Arkansas.

3) Eighty-two percent of the native species that occur in Baxter County on the Missouri border also occur in the West Gulf Coastal Plain of Louisiana and Texas.

4) Figure 2 summarizes the results of Method 4. Counties on the southern tier of Arkansas averaged around 18% and 19% of the sample, and counties on the northern tier averaged between 12% and 16% of the sample. No marked or abrupt shifts in flora were detected that correlated with the natural physiogeographic divisions of Arkansas.

5) Figure 3 summarizes the results of Method 5. No marked or abrupt shifts in flora were detected that correlated with the natural physiogeographic divisions of Arkansas.

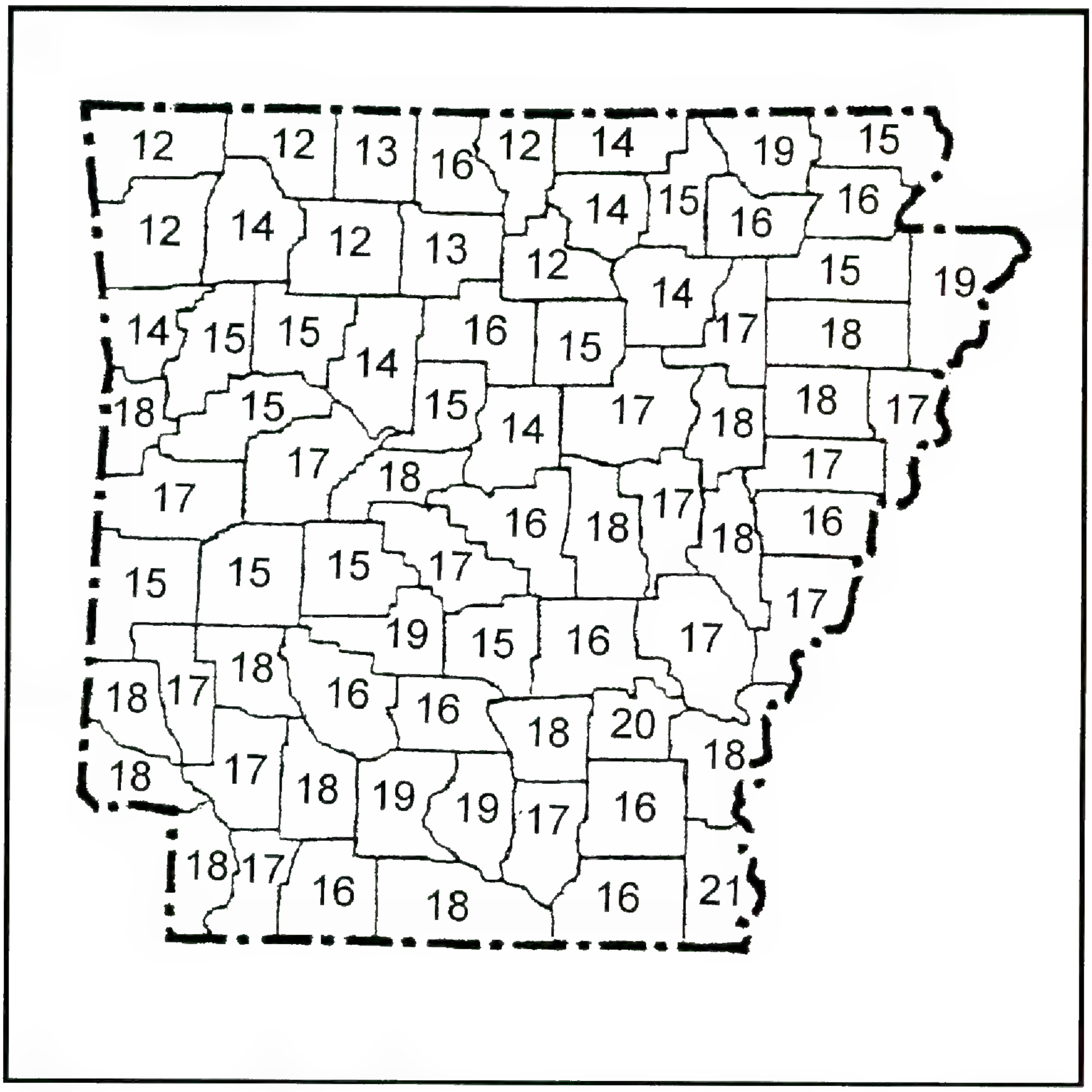


FIG. 2. Percent occurrence by county of 254 Louisiana species (see text for further explanation).

6) Figure 4 shows that the Ouachita Mountains has about 91% of its flora in common with the West Gulf Coastal Plain and the Ozark Plateau has about 82% of its flora in common with the West Gulf Coastal Plain. It also shows that the Ouachita and Ozark mountain/plateau regions are not only continuous floristically with the surrounding regions but virtually indistinguishable from them.

DISCUSSION

As noted in the introduction, biogeographers have presented a number of schemes for subdividing the Interior Highlands. These range from putting the Interior Highlands and Gulf Coastal Plain into separate biotic provinces or ecoregions to dividing the Interior Highlands into two provinces, and so on.

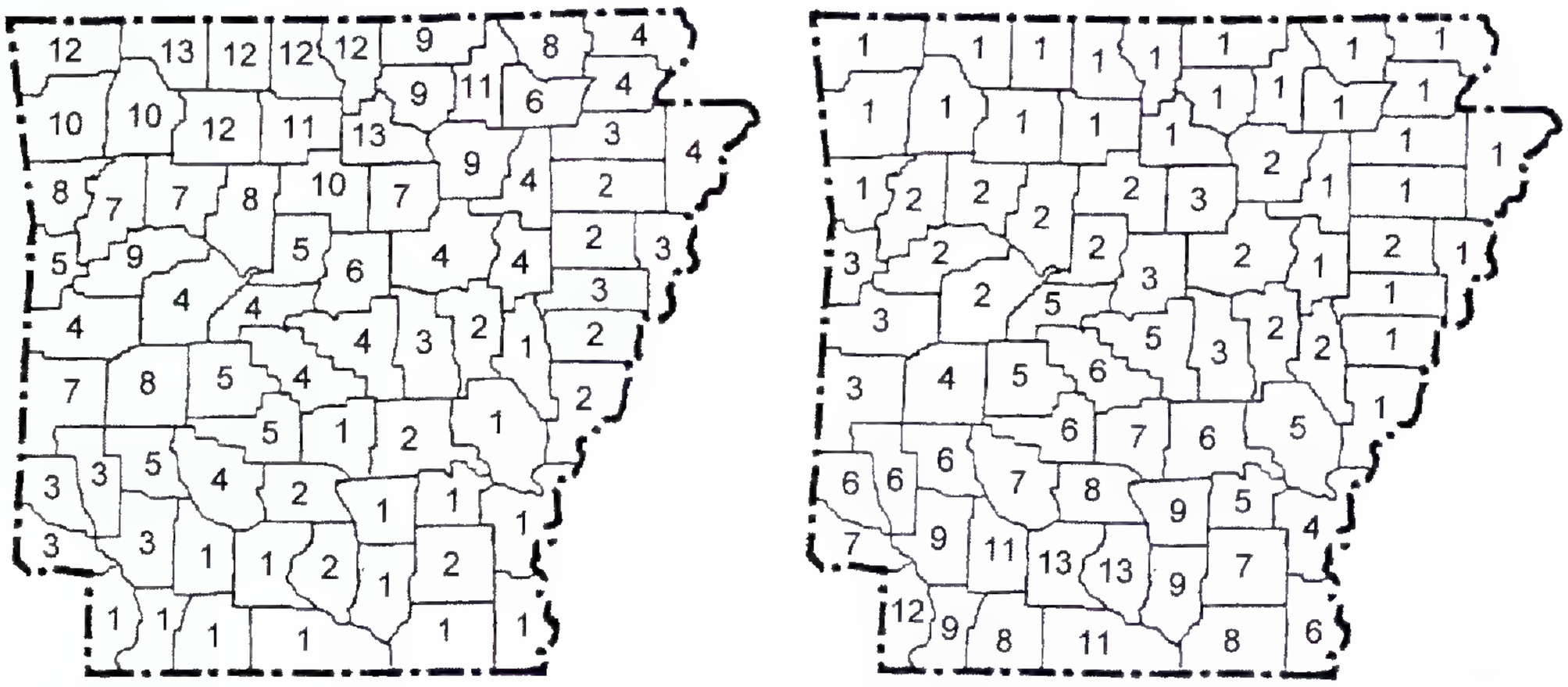


FIG. 3. Percent occurrence by counties of 227 Louisiana (left) and 272 Missouri (right) species (see text for further explanation).

Our analysis shows that the vast majority of plants occurring in north Louisiana and east Texas (West Gulf Coastal Plain) are also found in central and northern Arkansas. There is a gradual transition of species from the West Gulf Coastal Plain into the Interior Highlands and vice versa, and there are no marked or abrupt shifts correlated with the natural divisions of Arkansas, indicating that there are no major physiographical barriers. The only place we may have detected a possibly sharper transition is between the Ozarks and the Mississippi floodplain, but even here the transition is not precipitous.

The Interior Highlands are not floristically distinct from adjacent regions. The Ouachita flora as represented by Garland County, Arkansas, is closely related to the flora of all surrounding states especially Oklahoma, Louisiana, Mississippi, Tennessee, Kentucky, Alabama, Georgia, and the Carolinas (Fig. 4). The Ozark flora as represented by Newton County, Arkansas, is very similar to the Ouachita flora but, as would be expected, has a more northern affiliation. The Ozark region has its strongest floristic affinity with Oklahoma, Missouri, Illinois, Indiana, Kentucky, Tennessee, Ohio, Mississippi, Alabama, and Georgia (Fig. 4). If any generalization is necessary, the Interior Highlands as Zollner et al. (2005: 1788) have pointed out "shows surprisingly little floristic uniquity from surrounding regions."

Perhaps some or most of this lack of uniqueness is the result of movements of species north-south for the last two million years of 20 glaciations, with stragglers both north and south. This pattern of plant movement has been documented extensively, notably by pollen analysis but also by fossil plants (Givens & Givens 1987, Delcourt & Delcourt 2000). Also, edaphic conditions are not entirely dissimilar along this north-south continuum, with high rainfall and generally mild climates.

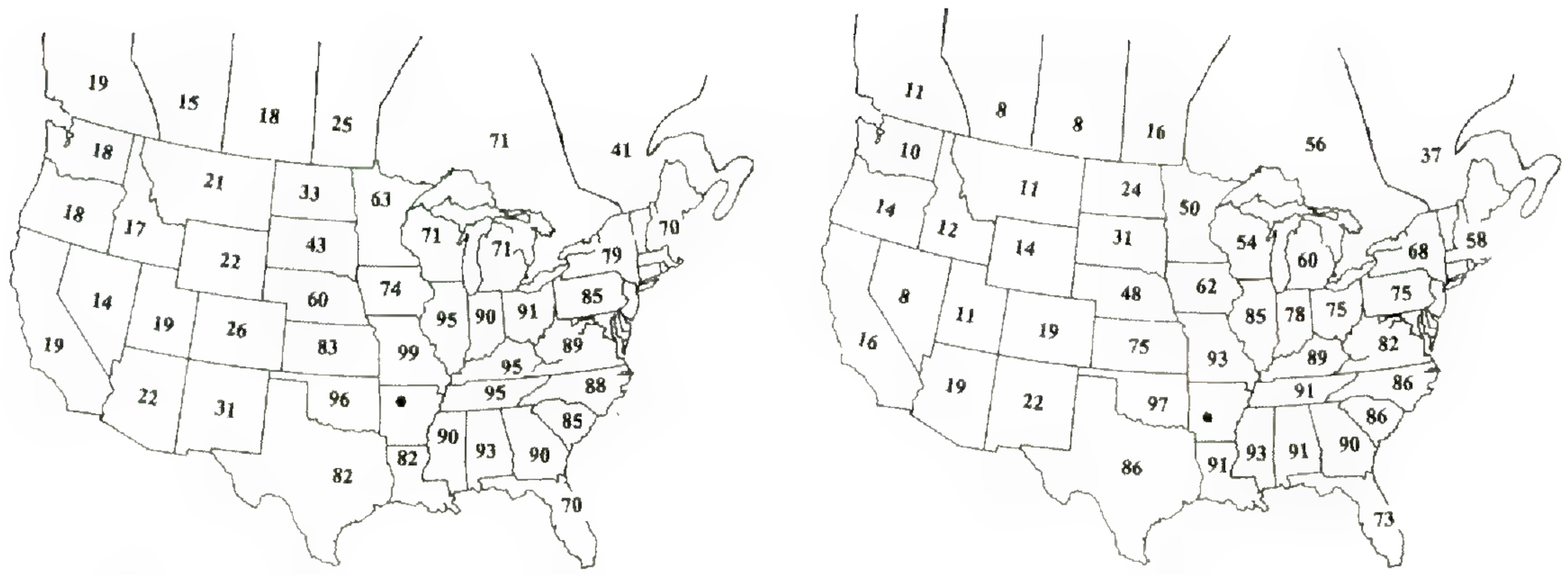


FIG. 4. North American floristic affinities of Newton County (left) and Garland County (right). Figures express percentage of species in common.

What these results mean for biogeographic classification and mapping is not entirely clear. Takhtajan (1986) has defined "province" differences as involving low levels of generic endemism and high levels of species endemism. "Ecoregion" is generally defined as a large area consisting of a distinct assemblage of natural communities and species with endemism being fairly high at the species and subspecies level (MacRoberts & MacRoberts 2004). The West Gulf Coastal Plain and the Atlantic and Gulf Coastal Plain have been the subject of recent endemic studies (Sorrie & Weakley 2001; MacRoberts et al. 2002). The West Gulf Coastal Plain has approximately 100 endemic taxa, three at the generic level. The Interior Highlands has only about 37 endemics, none at the generic level (Zollner et al. 2005). Setting aside the fact that no precise "index" has been proposed to test for provincial or ecoregional status, it seems from our analysis that the Interior Highlands and Gulf Coastal Plain are too similar floristically to be classified as different provinces or ecoregions. Perhaps some lower chorionomic category might better classify these two areas.

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HIGH LEVELS OF SEED INVIABILITY AMONG SEVEN POPULATIONS OF THE ENDANGERED SHORT'S GOLDENROD (*SOLIDAGO SHORTII*: ASTERACEAE)

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ABSTRACT

The physical conditions of mature seeds were examined from representatives of six Kentucky populations and one Indiana population of the endangered species Short's goldenrod (*Solidago shortii*, Asteraceae). A random sample of seeds from the Kentucky populations revealed the majority (71%–99%) were incapable of successful seedling development, being damaged due either to an insect predator or to unsuccessful fertilization or embryo abortion. Successful seedling development from phenotypically normal seeds ranged from 71% to 96% in the sampled Kentucky populations. The majority of the damaged seeds were necrotic, ranging from 62%–90%. The Indiana population exhibited the lowest level of herbivory (2%) observed for the species. Two congener goldenrod species (*S. canadensis* var. *altissima* and *S. nemoralis*) found growing either within or adjacent to three populations of Short's goldenrod exhibited lower levels of necrosis and higher levels of herbivory. A third congener species (*S. gigantea*) exhibited equal levels of the two seed conditions (herbivory and necrosis). The influence of seed inviability upon the persistence of natural populations of Short's goldenrod is at present unknown.

RESUMEN

Las condiciones físicas de semillas maduras de la especie amenazada "Short's goldenrod" (*Solidago shortii*, Asteraceae) fueron examinadas en seis poblaciones de Kentucky y una población de Indiana. La mayoría de las semillas de poblaciones muestreadas al azar en Kentucky, presentaron un número reducido de plántulas. Altos niveles de herbivoría, infertilidad, o aborto de embriones pueden explicar estas observaciones. Semillas normales encontradas en las poblaciones de Kentucky generaron plántulas que se desarrollaron con éxito en un 71% a 96%. En la mayoría de las semillas dañadas los niveles de necrosis fluctuaron en un 62%–90%. La población de Indiana presentó el menor nivel de herbivoría (2%) observado en la especie. En dos especies de "goldenrod" (*S. canadensis* var. *altissima* y *S. nemoralis*) distribuidas entre o cerca de tres poblaciones de "Short's goldenrod" se observaron bajos niveles de necrosis y altos niveles de herbivoría. En un una tercera especie de "goldenrod" (*S. gigantea*) se observaron condiciones similares de herbivoría y necrosis. Se desconoce la influencia de inviabilidad de semillas en la persistencia de poblaciones naturales de Short's goldenrod.

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INTRODUCTION

Short's goldenrod (*Solidago shortii*, Asteraceae) is an endangered species extant in the Blue Licks area of north central Kentucky and in one locality in Indiana (Homoya & Abrell 2005). A history of the discovery of this species, a description of the Kentucky localities in which this plant is currently found, and general features of the species' ecological life history are summarized in Baskin et al. (2000).

As with many endangered species, a key question remains unanswered: Why does this species have such a limited geographical distribution? In an effort to answer this question, an extensive body of knowledge has emerged regarding the autecology of Short's goldenrod (e.g. Buchele et al. 1989), involving investigations of both abiotic and biotic factors and their possible impact on the occurrence of this rare species. A later series of investigations implicated interspecific competition, primarily from introduced species, as being a leading candidate greatly interfering with establishment of Short's goldenrod seedlings (Walck et al. 1999a, 1999b).

One possible biotic component contributing to the rarity of the species is its reproductive biology, e.g. successful production of viable offspring. The first studies focusing on *S. shortii* seed germination were conducted by Buchele et al. (1991), that were later greatly expanded by Walck et al. (1997a, 1997b, 1997c, 1997d, 1997e, 1997f, 1999c). The primary (but not sole) emphasis in these studies was to determine the biotic and abiotic factors most responsible for successful seed germination and seedling survival and the range of conditions (e.g. light, temperature, moisture, cold stratification, etc.) required for optimum germination. In the first set of germination experiments (Buchele et al. 1991) seeds were obtained from two populations of Short's goldenrod; in the second set (Walck et al. 1997a) one population was sampled.

In our investigations involving the biology of Short's goldenrod, we noticed high levels of seed damage in individuals from several Kentucky populations and asked whether differences existed among populations in reproductive potential, i.e. the production of phenotypically normal seeds and developmentally normal seedlings. We posed the following questions regarding the reproductive biology of *S. shortii*. 1) What types of seed damage are present? What types of variation, if any, exists at the population level? Are some populations more prone to particular damages than others? 2) What quantitative variation, if any, exists both within and among selected Kentucky populations of Short's goldenrod in the levels of different types of seed damage and the production of normal seedlings? 3) Do the common congeners of *S. shortii* in the Blue Licks vicinity (i.e. *S. canadensis* var. *altissima* and *S. nemoralis*) and at the Indiana site (*S. gigantea* and *S. nemoralis*) exhibit similar levels of normal seed production as *S. shortii*? Are there statistically significant differences between the Ken-

tucky and Indiana populations of Short's goldenrod with respect to normal seed production?

MATERIALS AND METHODS

To address the first two questions, mature seeds (cypselae) of *S. shortii* were collected in mid-December 2001 from six Kentucky populations designated as #1, 2, 5, 7, 8, and 12 (Evans 1987; Smith et al. 2004). This time was chosen to ensure the collection of mature seeds, as noted in earlier studies (Buchele et al. 1991a; Walck et al. 1997a). The sampled populations are found within a 2.2-km area of Blue Licks Battlefield State Park in northern Kentucky, and were chosen due to the prevalence of flowering stems and physical accessibility. Ten individual stems were non-randomly sampled from each population as follows. The initial sampled plant stem was a minimum of 10 meters from the periphery of that specific population (based on the GIS mapping data from Smith et al. 2004). Due to the non-random distribution of these plants, the cluster of plants in closest proximity to the first sampled stem was then sampled, this process being repeated until ten plants were sampled. To maximize the probability of sampling separate genets, each sampled stem was separated from any neighboring sampled stems by at least 3 meters. Portions of mature infructescences were removed from the stems, placed in a paper coin envelope, and stored at 4°C in the dark for 12–16 weeks.

Following cold storage, the developmental fate of individual seeds sampled from the Kentucky populations in 2001 was followed by the use of 96-well microtiter plates (Fig. 1) as germination chambers prepared as follows. A minimal mineral salts medium (Hickok & Warne 1998) containing 1% agar was autoclaved and then aliquotted into each well (200 ml of medium/well) with a multichannel pipettor, then allowed to cool for 24 hours. Seeds were harvested by first scraping along the infructescence with forceps to dislodge the fruits and then collecting the seeds into a Petri plate. Single seeds were removed (without regard for condition) by grasping the fruit's pappus with forceps until the appropriate number of seeds was obtained. Each seed (in the majority of cases 24 seeds per plant, with exceptions noted below) was then carefully imbedded half its length into the solidified agar within a single well, with the pappus extruding above the medium. The plate cover was labeled with the location and identity of each seed source, secured with parafilm, and the plates incubated under the following conditions. A daily photoperiod of 14 hours was provided by a bank of cool white fluorescent lights (20W), that produced a photosynthetic photon flux (400–700 nm) at the germination plate level of approximately 20–25 umol m^{-2} sec^{-1}. The dark period temperature was 20°C and the light period temperature was 25°C. A seedling was scored as exhibiting positive Viable Seedling Development after emergence of the radicle and a mor-

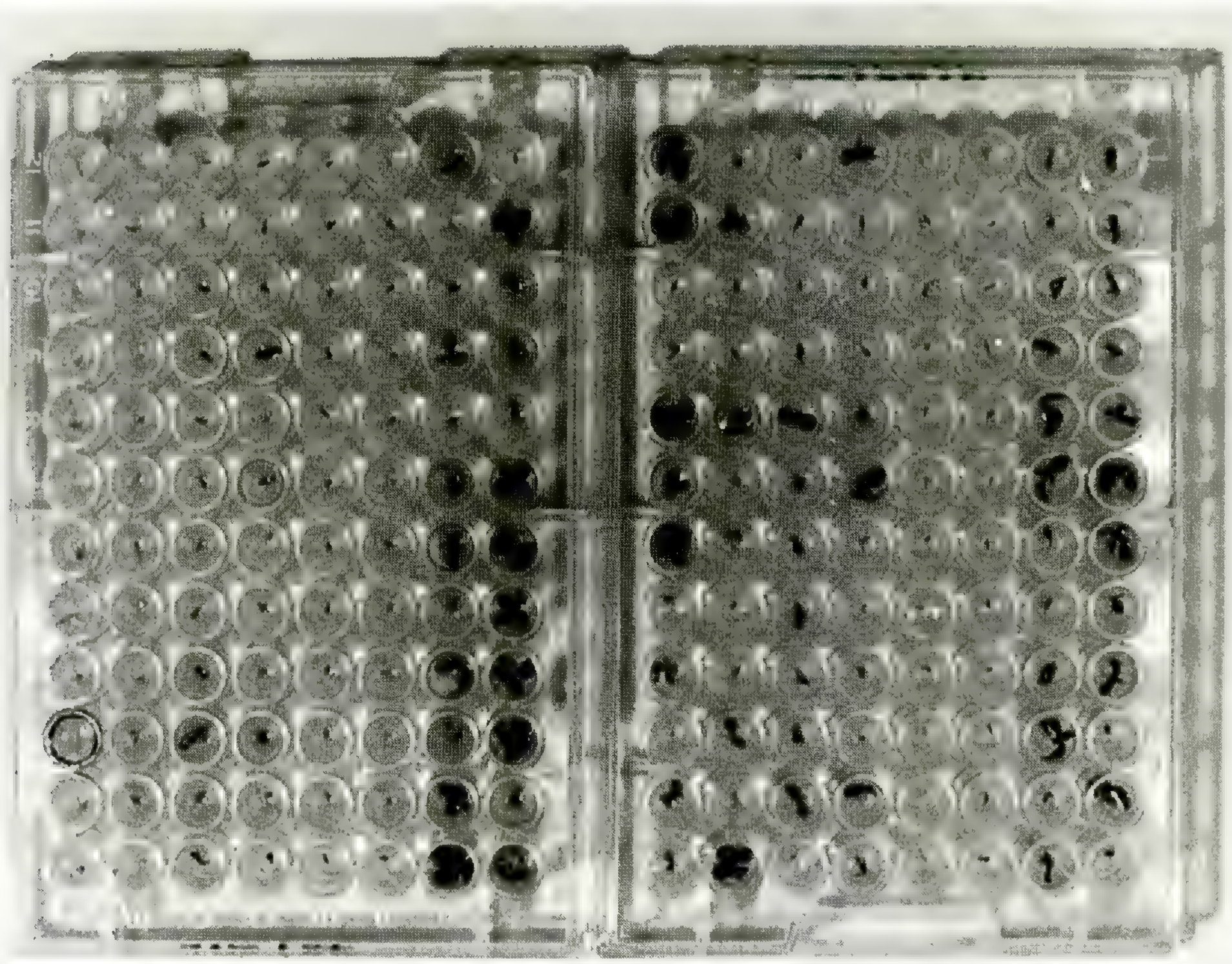


FIG. 1. An example of the seed germination assay conducted in 96-well microtiter plates. The first six vertical columns (1 seed/well) in the leftmost (facing) plate contain seeds that failed to germinate; the seventh and eights columns contain seedlings with fully emergent cotyledons that we categorize as positive Viable Seedling Development (VSD). For example, in column 8 well # (in descending order) 2, 6–10 all contain positive VSD individuals.

phologically normal set of cotyledons that persisted for at least one week post-emergence. All plates were incubated for 14 days.

Preliminary experiments.—Two preliminary experiments were conducted to address several experimental parameters. To determine if the damaged seeds were capable of either germination or forming normal seedlings, both necrotic and herbivore-damaged seeds sampled from 10 plants from each of the six populations (n=379) were incubated in germination medium for 14 days. In the second experiment the effect of cold-storage on seed germination was evaluated with a sample of phenotypically normal seeds (5 populations, 24 seeds/population) incubated in germination medium. Due to an insufficient number of normal seeds, data from population #12 were not included.

Intraspecific comparisons.—Our first experiment of this type involved the incubation of a random sample of seeds regardless of physical condition (n=1,440) from each of six populations in culture medium, to determine the level of viable seedling development (VSD) from a general sample. The second

analysis was conducted to determine the actual levels of normal vs. damaged seeds in a sample (n=1,199) from all six populations. For each population, 10 plants were sampled, 20 seeds per plant. For population #2, the seed sample size was n = 199. To address the issue of the level of seed damage due to either herbivory or necrosis, seeds from five populations were examined for physical condition (n=2,431). Ten plants from each population were sampled, typically 50 seeds per plant, the number of seeds varying in some cases due to availability. Due to an insufficient number of seeds, data from population #8 were not included. For the statistical analysis, sample size was reduced to 9 plants per population, due to the necessity of having equal sample size per population (all sampled populations had at least 9 plants with 50 seeds/plant, but not all populations had 10 plants with 50 seeds/plant).

Interspecific comparisons.—To address the third question mature infructescences were collected in mid-December 2003 in the Blue Licks vicinity from 10 plants of *S. shortii* and 10 plants of *S. canadensis* var. *altissima* from population #5, and from 10 plants of *S. shortii*, 5 plants of *S. nemoralis* and 5 plants of *S. canadensis* var. *altissima* from population #1. Seeds were collected from 10 plants of the Indiana population of Short's goldenrod and from 5 neighboring plants of *S. gigantea* and *S. nemoralis* each in mid-December 2004. For each examined plant, 20 seeds were sampled. Seeds from this final phase of the investigation were examined for their physical condition alone. For the Kentucky populations of *S. shortii* data from two different collecting seasons (2001 and 2003) are pooled as no statistically significant difference exists between the two seasons (t test; population # 1: t = 1.8, p =0.081; population #2: t = 0.33, p = 0.75). For the *S. canadensis* population data, two different populations (#1 and #5) are pooled as no statistically significant interpopulational difference exists (t test, t = 1.8, p = 0.12).

Statistical Analyses.—All statistical analyses were conducted using the software program SYSTAT version 11 (SYSTAT Software, Inc.). To test hypotheses of no statistically significant difference in values of the mean between or among groups, we used the t-test and analysis of variance (ANOVA), respectively, except in those cases when assumptions of these tests were violated. When the data were not normally distributed and/or group variances were heterogeneous, we used the Mann-Whitney Test or Kruskall-Wallis Test, which are nonparametric analogs of the t-Test and ANOVA, respectively (Zar, 1999).

RESULTS

Preliminary experiments.—In the first experiment in which damaged and necrotic seeds were incubated in germination medium, all were inviable as determined by the absence of either a radicle or a set of cotyledons. The second experiment using phenotypically normal seeds was conducted to determine the percentages of VSD using the cold storage treatment prior to incubation in seed

germination medium. The VSD values ranged from 71% (population #2) to 96% (population #8) (Table 1).

Intraspecific comparisons.—A preliminary visual examination of the Kentucky *S. shortii* seeds revealed two distinct morphological classes. Phenotypically "normal" seeds had a buff to tan color, were ellipsoid in shape (Fig. 2A), and several examined individuals contained fully developed embryos as determined by visual examination. The second class, consisting of physically damaged seeds, were of two types. One type exhibited either small holes bored into the seed/fruit coat (Fig. 2B) or a broken end. We term this group as being exposed to "herbivory," since the damage appears to be insect-induced. The second group, termed "necrotic," consisted of seeds that were either very dark brown to black, or were of typical color but deflated (Fig. 2C). An examination of several seeds of the former type revealed a shrunken, black mass assumed to be the remnants of an embryo.

Our first experiment of this type involved the incubation of a random sample of seeds regardless of physical condition (n=1,440) from each of six populations in culture medium, to determine the level of viable seedling development (VSD) from a general sample (Table 2). The levels of VSD were rather low ranging from 3% for population #12 to 33% for population #8. The differences in levels of VSD between populations are not significant (ANOVA, $F = 2.0$, $p = 0.097$).

To determine the actual levels of normal vs. damaged seeds, a second sample of seeds (n=1,200) from all six populations was examined (Table 3). The frequency of normal seeds in a population sample ranged from 1% (population #12) to 29% (population #1).

The next issue addressed was the level of seeds damaged by herbivory vs. necrotic seeds (Table 4; n=2,431). Five populations were sampled (all except population #8, due to an inadequate amount of seeds). The level of seeds damaged by herbivory ranged from 10% (population #5) to 38% (population #1). The differences between populations in terms of seeds damaged by herbivory was not statistically significantly different (ANOVA, $F = 1.9$, $p = 0.12$). For this analysis it should be noted that sample size was reduced to 9 plants per population, due to the necessity of having equal sample sizes per population (all populations had at least 9 plants with 50 seeds/plant, but not all populations had 10 plants with 50 seeds/plant).

Interspecific comparisons.—Levels of seed herbivory were similar between *S. shortii* population #5 and *S. canadensis* var. *altissima* populations #1 + 5 (16% vs. 18%, respectively) (Table 5). However, the levels of necrosis were significantly different—62% for the former, and 19% for the latter (Mann-Whitney Test, U=140, $p<0.0001$). Temporal differences for inviable seed production (combining the necrotic and physically damaged groups) between the 2001 and 2003 collections (Tables 3 and 5) were not significant for either population #1 ($t = 1.8$;

TABLE 1. Frequency of VSD (Viable Seedling Development) from phenotypically normal seeds subject to cold storage as determined by the emergence of a radicle and a complete set of cotyledons in a sample of phenotypically normal seeds.

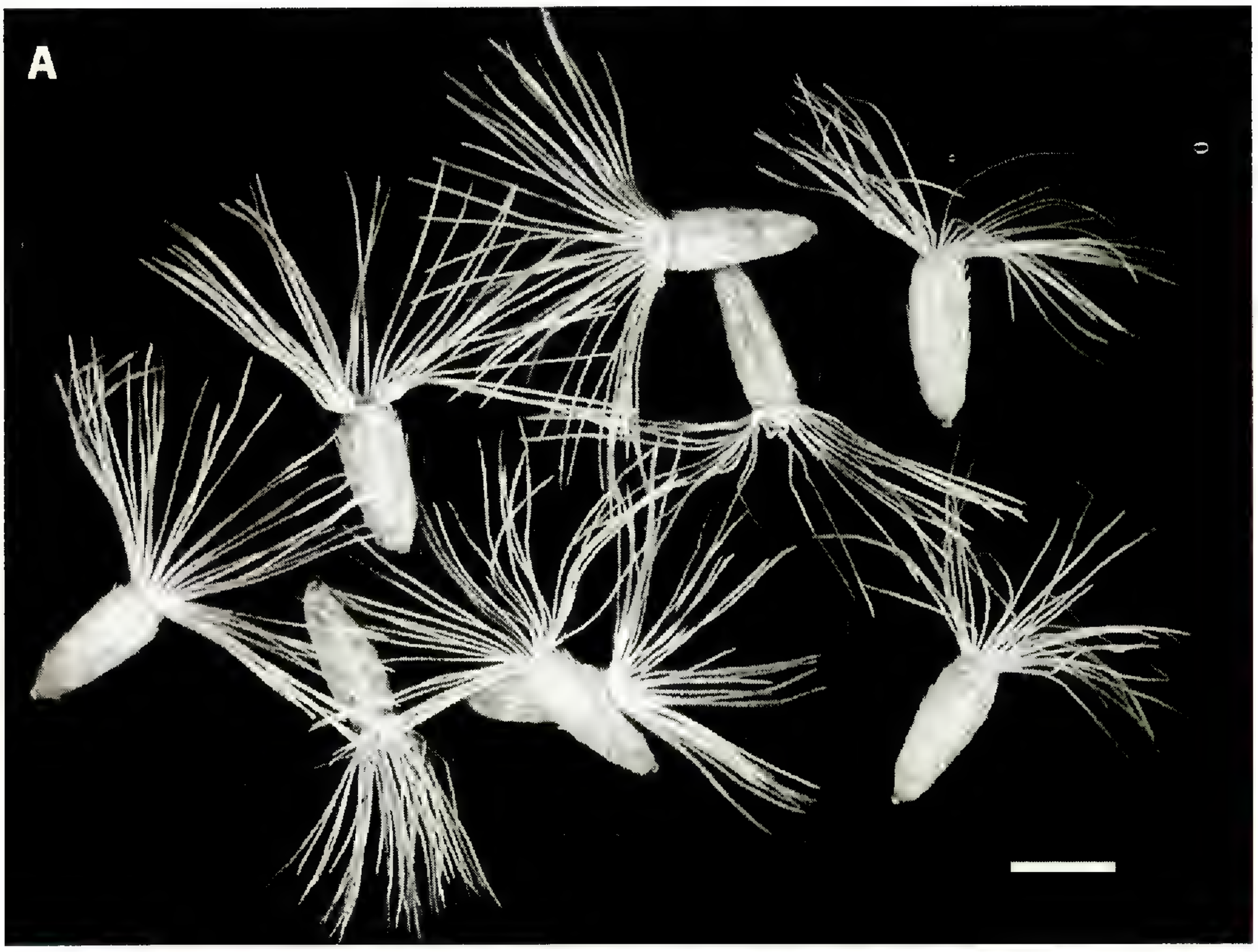
Pop'n	%VSD
1	88%
2	71%
5	79%
7	83%
8	96%

$p = 0.081$) or population #5 ($t = 0.33$; $p = 0.75$). Furthermore, there were no significant differences in inviable seed production between populations #1 and #5, as determined by the Mann-Whitney test ($U = 130$, $p = 0.064$). In comparisons of *S. shortii* with the local congeners in 2003, the percentage of normal seeds was much greater in the more common species (44% and 73% for *S. canadensis* var. *altissima* for populations #1 and #5, respectively, and 57% for *S. nemoralis* from population #1) (Table 5). Among the damaged seed sets, there was again significant *S. shortii* interpopulation variation for 2003: 36% of the total seed sample from population #1 being necrotic but 62% of the population #5 sample exhibiting similar necrosis.

The single Indiana population of Short's goldenrod exhibited a very high level of seed necrosis (74%) in comparison to the Kentucky populations (#1 - 36%, #5 - 62%). *S. gigantea* also had a rate of necrosis (41%) higher than that of the Kentucky congeners *S. canadensis* var. *altissima* (#1 - 21%, #5 - 9%) and *S. nemoralis* (14%). The percentage of normal Indiana seeds for *S. shortii* (25%) was higher than the overall mean among all six Kentucky populations (16%; Table 3). In comparing either of the Kentucky *S. shortii* populations (#1 and #5) with the Indiana *S. shortii* population, there was again no significant difference in inviable seed production (Kruskal-Wallis Test statistic = 3.7; $p = 0.16$).

There were no differences in inviable seed production between *S. shortii* and *S. canadensis* occurring syntopically in Kentucky for the comparison involving population #1 (t-Test, $t = 0.14$; $p = 0.89$) but yes for population #5 ($t = 5.3$; $p < 0.001$) (Table 6). Finally, there were no significant differences in inviable seed production between the Indiana population of *S. shortii* and the syntopic congeners *S. gigantea* and *S. nemoralis* (Kruskal-Wallis Test statistic = 2.6; $p = 0.28$).

The final comparison involved the levels of seed herbivory and necrosis among the three populations of *S. shortii*. The levels of herbivory did significantly differ between Kentucky population #5 and the Indiana population (Mann-Whitney Test: $U = 85$; $p = 0.005$), but not for population #1 vs. #5 ($U = 31$; $p = 0.14$) and population #1 vs. the Indiana population ($U = 68$; $p = 0.12$). For


A


B

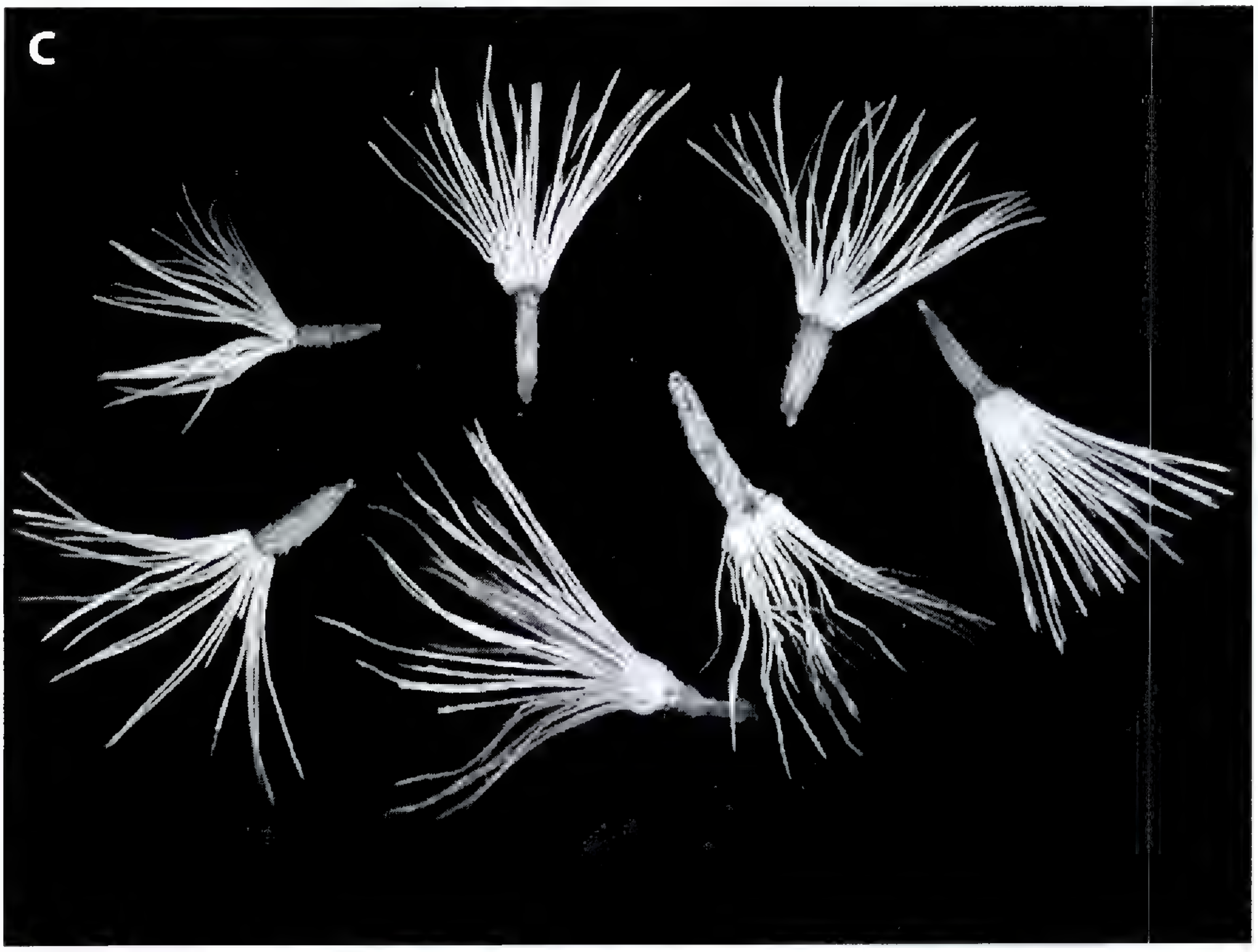


FIG. 2. Photomicrographs of the different seed conditions. **A** = phenotypically normal seeds; **B** = seeds subjected to herbivory (note the small holes bored into the seed coat; **C** = necrotic seeds (note the discoloration on some seed coats and the general "shrunken" appearance). The bar represents a length of 1 mm.

necrosis, populations #1 vs. #5 ($U = 21$; $p = 0.025$) and population #1 vs. the Indiana population ($U = 19$, $p = 0.021$) showed statistically significant differences. The difference between population #5 and the Indiana population was not statistically significant ($U = 28$; $p = 0.087$).

DISCUSSION

A number of embryo-lethal and mutant developmental alleles have been catalogued (e.g., Meinke 1994), and their existence in the homozygous state at a sufficient frequency within a population could have extreme consequences for the long-term persistence of that population. For that reason, in our tests for seedling viability, we measured the production of developmentally normal seedlings. In past studies of seed germination (see previously cited Buchele et al. and Walck et al.) the primary criterion for determining seed germination was emergence of the radicle after two weeks of incubation, as this is the definitive physiological indicator for completion of the germination process (Bewley 1997). The germination data in these prior studies was then transformed with data

TABLE 2. Levels of Viable Seed Development (VSD) from a random sample of seeds obtained from six populations of Short's goldenrod. All samples consisted of phenotypically normal as well as physically damaged and necrotic seeds. [1] = data from Smith et al. 2004.

Pop'n	%VSD	Pop'n size[1]	Density[1]
1	30%	2,549	0.842
2	21%	573	0.419
5	25%	3,488	0.648
7	14%	1,000	1.91
8	33%	672	0.877
12	3%	1,846	0.378

TABLE 3. Proportion of seeds from a random sample that were either phenotypically normal or damaged (either due to herbivory or necrosis).

Pop'n	% normal	% damaged
1	29%	71%
2	14%	86%
5	28%	72%
7	8%	92%
8	14%	86%
12	1%	99%

TABLE 4. Proportion of seed damage due to either external (herbivory) or internal (embryo abortion?) factors in a sample of damaged seeds from six populations of Short's goldenrod.. Damaged = seeds exhibiting a small hole in the coat, or a broken end; necrotic = seeds with a dark brown or black color, and a twisted, shrunken shape.

Pop'n (sample size)	% damaged	% necrotic
1 (464)	38%	62%
2 (487)	30%	64%
5 (490)	10%	90%
7 (500)	20%	80%
12 (490)	12%	88%

obtained from seeds that had not yet undergone germination, but that contained respiring embryos as determined by a histochemical stain (Cottrell 1947). Our criteria differ from the criteria previously used to determine seed germination, as we posed a different question.

Our interest in determining the frequency of developmentally normal seedlings produced from each sample of seeds was in obtaining an estimate of comparative reproductive potential. Those populations producing a higher frequency of developmentally normal seedlings would have a greater potential for persistence than a population with a low level of normal seedlings. Our

TABLE 5. Frequency of phenotypically normal vs. damaged seeds in two populations of Short's goldenrod containing congener species. Nor = phenotypically normal; Her = seeds exhibiting damage due to insect herbivory; Nec = seeds with a darkened and physically distorted external appearance. Populations #1 and 5 are from Kentucky; IN = the Indiana population. The parenthetical numerals refer to the number of plants sampled.

Pop'n	Taxon	Seed condition		
		Nor	Her	Nec
1	*S. shortii* (10)	54%	10%	36%
1	*S. canadensis* var. *altissima* (5)	44%	35%	21%
1	*S. nemoralis (5)*	57%	29%	14%
5	*S. shortii (10)*	22%	16%	62%
5	*S. canadensis* var. *altissima* (10)	72%	9%	19%
IN	*S. shortii* (10)	25%	1%	74%
IN	*S. gigantea* (5)	18%	41%	41%
IN	*S. nemoralis* (5)	43%	45%	12%

TABLE 6. Summary statistics (mean ± 1 SD and range) for the number of inviable (necrotic + damaged) seeds from a single sample per plant for Kentucky (#1 and #5) and Indiana (IN) *S. shortii* and Kentucky (#1+#5) *S. canadensis* populations.

Pop'n	Taxon	Mean	Range
1	*S. shortii*	12 ± 6.3	3–20
5	*S. shortii*	15 ± 4.0	8–20
IN	*S. shortii*	15 ± 4.1	5–19
1+5	*S. canadensis*	7.4 ± 6.0	0–20

specific question was not one of seed germination rates among and between populations, but one of the frequency of normal seedling production. We employed incubation conditions that would, based on previous studies (e.g. Walck et al. 1997a) optimize seed germination levels, then examined seedlings for normal early development.

During the course of this study, of considerable surprise to us were two discoveries: the frequencies of seed predation (herbivory) and necrotic (presumably embryo aborted) seeds. All seven sampled populations experienced marked levels of either mechanically damaged seeds or necrotic seeds. The number of affected seeds (either damaged or necrotic) in our samples ranged from 70% (population #1) to 99% (#12). Of the damaged seed sets, the majority were necrotic, ranging from 63% (population #1) to 90% (#5). Seed damage in populations 1 and 7 was previously noted "in some infructescences" and attributed to larvae of the family Cecidomyiidae (Diptera) (Buchele et al. 1992). There were no quantitative data in this earlier report. Another possible candidate is bruchid beetle larvae (R. Kingsolver, pers. comm.).

There is no previous mention in the literature concerning *Solidago* regarding the occurrence of necrotic seeds in mature infructescences. The major threat to successful formation of developmentally normal seedlings appears not to be an external agent, e.g. an insect depositing eggs in *S. shortii* seeds as a food source for developing larvae, but rather the frequency of embryo-aborted seeds. There could be three possible explanations for the phenomenon of embryo abortion. First, due to the small sizes of the populations (Smith et al. 2004) it is possible that through stochastic events lethal allele combinations have arisen (Levin 2000) possibly leading to embryo abortion. Second, there could be pollen competition among Short's goldenrod plants and the more common goldenrod species. There is a temporal overlap in anthesis between the three goldenrod species at Blue Licks, and we have observed individual insects visiting inflorescences of all three goldenrod species. Likewise plants of the Indiana population of Short's goldenrod could have been pollinated with pollen from either *S. nemoralis* or *S. canadensis*, leading in both cases to abortive embryo formation due to gametic incompatibility (Grant 1971). Third, as *Solidago* is an obligate outcrosser (Buchele et al. 1992) lack of suitable crosspollination would lead to unfertilized embryo sacs and arrested development of the resultant seeds (Proctor et al. 1996). At present there are no data available to distinguish among these three possibilities.

It is difficult to assess the impact of reduced seed production on the persistence of *S. shortii*, given that three more widespread congener species (*S. canadensis* var. *altissima*, *S. nemoralis* and *S. gigantea*) are likewise subject to seed predation. The presence of congener species with a lower level of necrotic seeds (and assumedly a pre-predation higher level of normal seeds) does not appear to influence the behavior of the seed predators on Short's goldenrod, as there was no statistically significant difference between populations that contained (#1) or were adjacent to (#5 and the Indiana population) congener species and those without. In the absence of interspecific competition, Walck et al. (1999a) observed successful establishment of Short's goldenrod seedlings in field plots over a three-year period. Given the large number of florets in a typical Short's goldenrod inflorescence, there evidently are a sufficient number of viable seeds generated to provide for some level of sexual reproduction.

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NATURALIZATION AND EXTIRPATION OF WATER HYACINTH (*EICHHORNIA CRASSIPES*, PONTEDERIACEAE) IN SOUTHWESTERN ARKANSAS, U.S.A.

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ABSTRACT

Southern Arkansas appears to be at the edge of the potential range for naturalization of the water hyacinth, *Eichhornia crassipes* (Martius) Solms, due to the cold intolerance exhibited by the plant. A population discovered growing in DeGray Lake, Clark County, Arkansas, was examined from 2002–2003 to determine whether the population could survive after the freezes common during winter. The population was of particular interest because it had become rooted and remained submerged with higher lake levels during the surface freezes of winter. Rosettes that fragmented from the population established new growth during the next growing season, but fluctuating lake levels eventually stranded this growth and caused extirpation of the population.

RESUMEN

Arkansas meridional parece estar en la frontera del rango potencial para la naturalización del jacinto de agua, *Eichhornia crassipes* (Martius) Solms, debido a la intolerancia al frío exhibida por la planta. Una población se descubrió creciendo en el Lago DeGray, Condado de Clark, Arkansas, se examinó entre 2002–2003 para determinar si la población podría sobrevivir después de las heladas comunes durante el invierno. La población era de interés particular porque había llegado a arraigar y quedaba sumergida con los niveles más altos de lago durante las congelaciones de la superficie en invierno. Rosetas que se fragmentaron de la población tuvieron crecimiento nuevo en la siguiente estación de crecimiento, pero los niveles fluctuantes del lago desfavorecieron finalmente este crecimiento y causaron la extinción de la población.

INTRODUCTION

Eichhornia crassipes (Martius) Solms (water hyacinth) is one of two naturalized species of *Eichhornia* found in the United States (Horn 2002; Wunderlin 1998). Water hyacinth is native to tropical South America, specifically Amazonia (Barrett & Forno 1982). Water hyacinth now occurs in over 50 countries across five continents (Barrett 1989). It is believed that *Eichhornia* was introduced into the United States at a Centennial Exposition at New Orleans in 1884 (Penfund & Earle 1948). It is one of the most aggressive aquatic weeds in the tropics, doubling its population as quickly as every 11–18 days (Penfund & Earle 1948). Further, *Eichhornia* is known to produce physiological changes to the aquatic environment (Center & Spencer 1981; Fitzsimmons & Velljos 1986; Penfund & Earle 1948; Ultsch 1973). Seed production in temperate regions is

usually only about one-half of that in the tropics, primarily because of differences in levels of insect visitation (Barrett 1980).

Eichhornia crassipes is only marginally cold hardy and is completely destroyed when the rhizome is exposed to temperatures at or below -5°C for 12 or more hours (Penfund & Earle 1948). Water hyacinth should not reliably establish in areas where these temperature conditions occur annually. In southwestern Arkansas, air temperatures reach this level for several days during most winters, which likely would limit the yearly regrowth of populations of *Eichhornia*.

However, a population of *Eichhornia crassipes* was discovered in a cove of DeGray Lake, Clark County, Arkansas on 28 January 2002. Living rosettes with broken stolons were discovered along the north shoreline, and a search to reveal the source of these usually floating plants led to the discovery of the population submerged in the lake waters. We followed the fate of this population, to determine whether the submerged condition would allow survival through the winter due to protection from freezing. It was presumed that the typically clear water would allow adequate photosynthesis to carry the population until the next growing season.

METHODS

The source of the original established population was not known. Upon further search, the only locality found supporting plants was the initial discovery along the north shore of the cove. Prevailing winds from the south presumably pushed floating rosettes into the north shore of the cove and effected establishment at the site. We assumed that the population was established during the previous summer. Numerous old inflorescences were discovered still attached to the rosettes of the population.

We returned to the site on several occasions during 2002 to determine the fate of the population. Water temperature (surface and at one meter) and depth of the population was measured when possible.

During 2002, several rosettes collected from the field site were grown in the lab and in a small plastic outdoor pond to determine whether the plants would flower and produce viable seed. With the onset of winter 2003, a few of these rosettes were planted in pots and submerged to determine whether such overwintering plants would produce break-away rosettes that would establish a new population during spring.

RESULTS

The submerged lake population on 28 January 2002 had rosettes of 15–20 cm width. The water depth at the location of the deepest specimens (the water in the cove was perpetually clear, allowing us to see the plants) was 90 and 107 cm, but most rosettes were located at a depth of 80–85 cm. The widest portion of the population (about 1 m wide) was located toward the head of the cove,

where the slope of the substrate was more gradual and the water was shallow, but most of the population occurred in a strip about 1/2 m wide by 80 m long along the contour of the shoreline. Samples of the rosettes showed old inflorescences.

Plants toward the head of the cove exhibited morphology more typical of floating rosettes, but most other specimens had small floats and an upright elongate central or main stem. Temperature at the surface on 28 January was 12°C, and at one meter was 10°C.

On 15 February, the population looked as it had previously, but the lake had risen about 25 cm so that most plants were at a depth of 105–110 cm. Sediments occasionally produced by wave action were deposited as a film over the population, although sampled plants still were green. Many plants had become separated from the submerged mat and were floating near shore. Temperature was 9°C at the surface and 8°C at one meter.

On 24 April, water depth had increased again, making the rosettes impossible to see. Several rosettes that had separated and floated now were rooting into the sediments along the elevated shoreline, and 10 of these were marked to follow their survival. Several green rosettes were trapped among debris at the head of the cove, protected from waves created by boaters. Also, eight rosettes were found in the last 15 m of the cove along the southern shoreline. Temperature was 23°C at the surface and 21°C at one meter.

By 9 May, water depth had increased again, placing the population at an estimated 1.5–2 m depth. The plants rooted into the sediments and marked during the previous trip now were submerged and not relocated. Along the shoreline, we counted about 40 rosettes that recently had broken free of the original population, many at the head of the cove. One of these was partially buried in the wet sandy soil about 1.5 m from water. Most of these stranded rosettes were small (3–10 cm width), but had new growth and new roots were evident. Temperature was 23°C both at the surface and at one meter.

On 12 June, the highest water level we observed kept the original population, if still alive, submerged beyond visibility. Wind action had placed all floating rosettes (the 40 observed on 9 May) along the shore near the head of the cove. These plants now were larger (8–20 cm width), had new growth, and included clusters with side branches. The specimen partially buried in the sand on the previous date was not relocated, and all plants found were floating with the exception of a few stranded at the head of the cove by wave action. Temperature was 31°C at the surface and 29°C at one meter.

On 18 July, depth of the lake had decreased about 3/4 m and the water was very clear, but the original population of *Eichhornia* had disappeared. Only 18 rosettes of the 40 were surviving. These were found in 8 clusters all near the head of the cove in muddy to sandy areas covered by organic debris and in almost constant shade. The roots of these plants had become anchored in sedi-

ments, and now had rosettes up to 30 cm in diameter and side branches with upright leaves with small bladders. These plants were in wet soil located 5–9 m from the water of the lake. Temperature was 29.5°C at the surface and 29°C at one meter.

On 9 August, the few remaining exposed plants were drying and dying back, with the healthiest three clusters located 5, 5, and 22 m from the lake in the sandy soil of the head of the cove. Rains fell before 6 September, which apparently rejuvenated the plants and permitted new growth of leaves. Additional rain fell before a 20 September visit, and had resulted in continued new growth.

On 7 January 2003, the site was revisited with the expectation that the frost of 25 November would have killed the remaining plants that had been isolated in exposed locations along the cove. Of the last 18 rosettes, only two were relocated – dead and submerged under 20 cm of water.

In the small pond experiment, the rosettes proliferated and filled the pond during the summer, and produced numerous inflorescences from 6 August through September. However, all surface plants were killed with the first frost. The frost killed only exposed portions of 5 otherwise submerged plants. The remaining portions of these 5 plants remained green until early spring, then died. No new rosettes were able to break away, surface, and proliferate during the next spring. Seeds left in the pond and those used in greenhouse experiments failed to germinate within one year, and no germination of seeds has been discovered at the field location. It is important to note that the seeds used in our experiments were not intentionally scarified to promote laboratory germination.

DISCUSSION

A population of *Eichhornia crassipes* became established in DeGray Lake, at a northern latitude presumably marginal for this cold-intolerant plant to overwinter outdoors. The original established population survived through periods of freezing because the root system anchored the plants, not allowing them to float as the level of water in the lake rose during winter. Although the original population did not survive the entire winter, rosettes that periodically broke free and floated survived if they surfaced after the last freeze.

The higher level of water during spring deposited these surviving rosettes higher up the bank than the original population. Some survived and grew during the next season, but they became exposed and isolated from the lake as water levels dropped during summer. Because none of the originally submerged plants were observed after 18 July, none was present for future re-establishment.

From the available data, we believe that the original population was established during the summer of 2001 when the lake level was near its seasonal low. Plants grew along the shoreline, held there by the winds, and became anchored by their roots. Any plants that grew across the deeper water of the cove, and were not held by the roots as the water level rose, would have died with

freezing air temperatures. This scenario would have left the observed 80 m long, 0.5–1 m wide population that followed the contour of the shoreline. This portion of the original population actually survived the winter by being submerged, and re-established and grew the following spring. However, fluctuating lake levels led to the extirpation of the population that had established.

Penfund and Earle (1948) unexpectedly observed that *Eichhornia crassipes* plants died while submerged during the winter. They felt that protection from the freezing surface temperatures would protect the plants, but argued that a lack of oxygen might have explained the death of their submerged population. Because even clear water filters light, we argue that insufficient light to the submerged plants might have precluded adequate photosynthesis. Further, water saturates with much less oxygen and carbon dioxide than is available in air, which likely contributed to the observed death of the rooted population in our study.

Eichhornia crassipes has a means of survival when a rooted population becomes inundated. Penfund and Earle (1948) found that 10 days after submergence, *E. crassipes* begins to produce an abscission layer across the rhizome just below the lowest living leaves, forms new roots just above the abscission layer, and floats to the surface. Those new rosettes could continue the existence of the population if surface conditions were within the range of tolerance.

Seedlings of *E. crassipes* can survive submergence via the same mechanism (Penfund & Earle 1948; Robertson & Thein 1932). Seeds of *E. crassipes* only germinate when exposed to air, and thus seeds that germinate on areas where water has receded could become rooted and attached into the soil substrate, and subsequently submerged if the water level of the lake rises. We did not observe seedling development in our field or lab studies, so we found no evidence that re-establishment would occur by those means at our site.

We believe that this species would be able to survive at our site if the seasonal high and low water levels were less different, or if the relative timing of lake fluctuation and freezes afforded protection. Thus, submerged plants would have a greater chance of surviving longer into the winter and spring, and separating rosettes would not meet high water and be placed too far away from the lake to undergo the rapid growth possible during summer. The present conditions appear to help prevent the long-term establishment of this exotic plant at this site.

ACKNOWLEDGMENTS

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FUNGI ASSOCIATED WITH *BORRICHIA FRUTESCENS* (ASTERACEAE): INSECT GALLS AND ENDOPHYTES

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ABSTRACT

This report compares fungi found in galled and non-galled plants of *Borrichia frutescens* (L.) DC., Asteraceae. Fungi were observed in the plant galls of the midge, *Asphondylia borrichiae* Rossi & Strong. A variety of endophytic fungi were cultured from the apical meristems, stems and leaves of galled and non-galled plants collected from several coastal sites in Florida. Fifteen percent of midges examined ($n = 60$) carried fungal spores of *Alternaria* sp.

RESUMEN

Este artículo compara los hongos encontrados en plantas con y sin agallas de *Borrichia frutescens* (L.) DC., Asteraceae. Se observaron hongos en las agallas de *Asphondylia borrichiae* Rossi & Strong. Se cultivó una variedad de hogo endofítico de los meristemos apicales, tallos y hojas de plantas con y sin agallas colectadas en varios lugares costeros de Florida. El quince por ciento de las agallas examinadas ($n = 60$) tenían esporas de *Alternaria* sp.

INTRODUCTION

Borrichia frutescens (L.) DC. or bushy seaside oxeye is a perennial herbaceous Asteraceae often found bordering the salt marsh communities of the Gulf of Mexico and Atlantic Ocean. Insect galls on this host species are initiated in the apical meristem by a midge, *Asphondylia borrichiae* Rossi & Strong (1990). These galls are also impacted by four specific parasitoid wasps (*Galeopsomyia haemon* Walker, *Rileya cecidomyiae* Ashmead, *Tenuipetiolus teredon* Walker, and *Torymus umbilicatus* Gahan). Individuals from these parasites lay their eggs inside the gall with *A. borrichiae*. The parasitoids devour the developing midges and significantly affect population levels of *A. borrichiae* (Rossi et al. 1992). Several biological studies on this plant midge system elaborate on the life history and ecological details including parasitism rates (Rossi & Strong 1990; Stiling et al. 1992; Stiling 1994; Rossi & Stiling 1998; Rossi et al. 1999). As in many insect galls, the tissue surrounding the developing larvae eventually becomes full of chambers layered with fungal growth purportedly providing nutrition for the developing larvae (Gagne 1989). Thus, knowledge of the fungi associated with both the galled and non-galled plants is needed to gain insight into this host-parasite relationship.

It is unclear how fungi are introduced into the galls in the *B. frutescens* system. Many plants are known to harbor microbial endophytes which predomi-

nantly are fungi. These organisms live internally in plant tissue. Stone et al. (2000) suggest that these endophytes secondarily invade insect galls. Batra and Lichwardt (1963) indicate that "gall fungi are airborne, grown in a variety of substrata and are not species specific." Other investigators of insect galls suspect that spores of fungi are accidentally collected from leaves and leaf litter by the insects (Borkent & Bissett 1965). Haridass (1987) suggests that fecal contamination is another possible means of spore dispersal whereby fungi are introduced into the plant tissue. Gagne (1989) reports that midges feed by sucking on the hyphae and states, "fungi are evidently obligatory in all galls...and are food of those gall midges." Batra and Lichwardt (1963) alternatively indicate that it is difficult to determine whether midges actually feed on the hyphae or the plant tissue degraded by the fungi.

In this study we examined a number of midge galls of *Asphondylia borrichiae* from *Borrichia frutescens* from several Florida sites for the presence or absence of fungi. In addition plant apices, stems, and leaf samples of galled and non-galled plants were cultured for fungi. Finally, a small population of midges was surveyed for associated fungal spores.

MATERIALS AND METHODS

Sites for Collections.—*Borrichia frutescens* galls, leaf and stem samples were collected from the following locations from 1993–1995 in Florida:

Site #1–Merritt Island National Wildlife Refuge, Titusville (Brevard County).

Site #2–Little Jetties Park, Mayport (Duval County).

Site #3–Ft. DeSoto State Park, St. Petersburg (Pinellas County)

Site #4–Upper Tampa Bay Park (Hillsborough County).

Site #5–Delnor-Wiggins State Park, Naples (Collier County).

Culture Protocol.—In May, 1995, five samples each of apex, stem, and leaf tissue were collected from galled and non-galled plants from Sites 1, 2, and 3. All collected plant samples were placed in individual, sterile plastic bags, refrigerated, and returned to the laboratory within three days. Excised tissue from apices, stem and leaf tissue of both galled and non-galled plants tissues were rinsed in running water for 5 min, then each tissue type was placed in separate flasks and rinsed with 95% ethanol for 2 min. This was followed by a 30 min shake rinse in 20% bleach solution. All tissues were held in flasks of sterile distilled water (1- 2h) while tissues were prepared for incubation. Three slices from each tissue from each site were submerged in Potato Dextrose Agar (PDA) and V-8 Juice Agar (Difco, Detroit, MI). These cultures were placed in a dark incubator at 32°C for seven days. Isolates from successful cultures were placed on PDA slants and held at ambient temperature until sporulation after which identifications were made.

In Situ Fungal Studies.—In September, 1995, ten stems were collected randomly from galled and non-galled plants of *B. frutescens* from four sites (# 1–4). Each stem was cut into 1.5 cm segments. Using the protocol established by Hignight et al. (1993) stems were cleared and then all segments were microscopically examined for the presence of endophytes.

Direct Observations of Insects.—Whole insects of *Asphondylia borrichiae* were collected as they emerged from galls of *Borrichia frutescens*, ($n = 60$), *Iva imbricata* Walter ($n = 20$), and *Iva frutescens* L. ($n = 5$) and preserved in vials of 95% ethanol. All insect samples were examined for the presence or absence of fungal spores on the surface using light microscopy.

RESULTS AND DISCUSSION

Previous dissection of the *Borrichia frutescens* galls revealed larval chambers (pers. obs.). Within these white mycelium could be observed and this fungal growth was arrested until the larvae became fully developed. Then the mycelial mat became denser, darker, and quite distinct (Fig. 1).

Midge galls observed in the Asteraceae, and fungi isolated from those galls are listed in Table 1. In addition, Farr et al. (1989) note the occurrence of *Aecidium borrichiae*, *Puccinia mirifica*, and *Cercosporidium* sp. on stems and leaves of *B. frutescens*. Although many plants have fungal endophytes (Clay et al. 1985; Clay 1990; Carroll 1988), prior to this they were not known from *B. frutescens*.

Preliminary studies (1993–1994) including direct observations and excising and culturing of a range of ages of gall tissue from *B. frutescens* from all five sites consistently yielded a large variety of fungi including two types of sterile mycelium (data not shown). Similar observations have been made in other studies of midge galls. Bissett and Borkent (1988) report that some midges from the Lasiopterini and Asphondylidi inoculate galls with a variety of mitosporic fungi and use them as a food source. Stone et al. (2000) observed that galls on Douglas-fir (*Pseudotsuga menziesii*) support heavy fungal growth which, he suggests, may be plant pathogens in addition to providing insect nutrition. Wilson (1995) proposes that fungi in galls may be saprobes or inquilines (organisms inhabiting insect galls not parasitizing the gall maker but otherwise utilizing the gall tissue for food).

To determine if endophytic fungi could be observed microscopically and using the method of Hignight et al. (1993), a preliminary study was conducted in May 1995 using five stems each from galled, non-galled, flowering non-galled and flowering galled plants of *B. frutescens* collected from Site #3, Ft. Desoto. This mini-study revealed that endophytic fungi were present in 100% of the samples from plants with galls appearing similar to the example seen in Figure 2. The remaining non-galled stems were less heavily colonized with fungi. This qualitative observation led to additional studies to quantify endophytic fungi

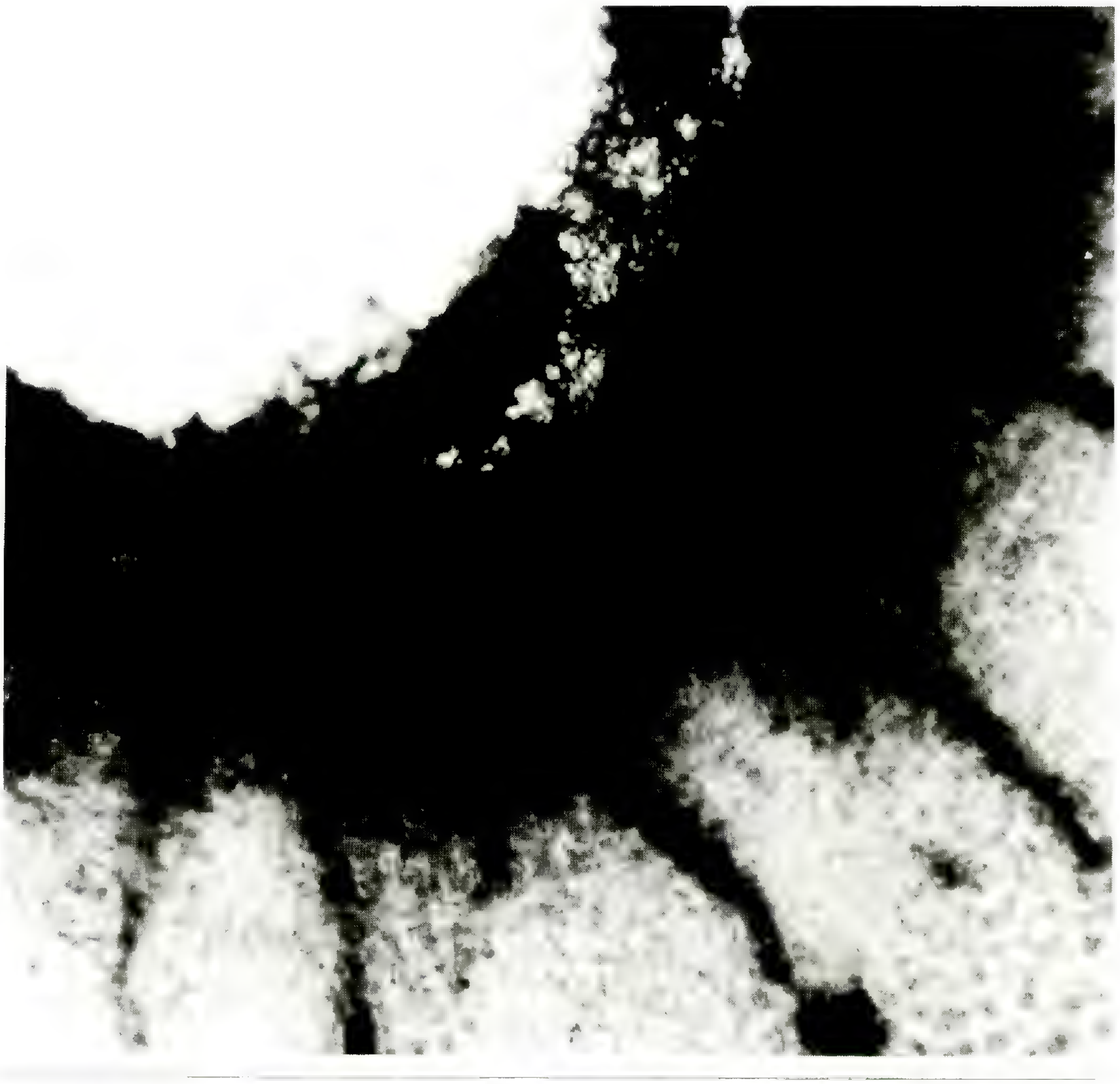


FIG. 1. *Borrichia frutescens*. Cross section through a gall showing the layer of the fungal mycelium.

involved in the stems of galled and non-galled plants. We observed a consistent occurrence of endophytic fungi in all sampled stem segments from four diverse Florida locations (Sites 1–4). In all non-galled plants these occurrences range from 20 to 64% and in galled plants 30 to 64%. This suggests little influence of the role of the midge. But one might argue that the fungal endophytes in galls grow out, invading other plant tissue. On the other hand, depending on the time-frame, endophytic fungi may grow into the gall or exist in the pre-gall tissue and contribute to the mycoflora of the aging gall. Either way, fungal endophytes are extant in *B. frutescens*.

In the apices, stems, and leaves of both galled and non-galled plants from Sites 1, 2, and 3 several fungal taxa occur (Table 2). Included among the isolates are several types of sterile mycelium. These were found among all tissue types. *Alternaria* sp. was also found among all tissue types (Table 2). *Acremonium strictum*,

TABLE 1. Fungi reported in gall midge associations in Asteraceae.

Gall midge	Host	Fungi	Reference
Asteromyia carbonifera	*Solidago canadensis*	*Sclerotium asteris*	Weis 1982; Batra 1964
A. tumifica, A. modesta A. carbonifera	*S. mollis*	*Macrophoma* sp.	Borkent & Bissett 1985
A.carbonifera	*Aster* sp.	*Rhytisma asteris*	Batra 1964
A.carbonifera	*S. sempervirens*	*R. bifrons*	Batra 1964
A.carbonifera	*S. lanceolata*	*R. solidaginis*	Batra 1964
A. ratibidae	*Ratibida columnifera*	*Chaetomium globosum*	Batra 1963
A. ratibidae	*R. columnifera*	*Aureobasidium pullulans*	Batra 1963
A. ratibidae	*R. columnifera*	*Plectosporium tabacinum* (as *Cephalosporium ciferrii*)	Batra 1963
A. carbonifera	*S. graminifolia*	*Alternaria* sp.	Batra 1963
Bucculatrix simulans	*Helianthus* sp.	*Trichoderma viride*	Batra 1963
B. simulans	*Helianthus* sp.	*Aspergillus* sp.	Batra 1963
B. simulans	*Helianthus* sp.	*Trichothecium roseum*	Batra 1963
B. simulans	*Helianthus* sp.	*Penicillium* spp.	Batra 1963
B. simulans	*Helianthus* sp.	*Stemphylium* sp.	Batra, 1963
B. simulans	*Helianthus* sp.	*Botrytis cinerea*	Batra 1963

Bipolaris sp., and *Verticillium lecanii* displayed more irregular distribution in the plant tissues from the sites sampled. Other species of these genera have been reported in the endophytic fungal literature (Bacon & White 2000).

The mycangia (small special pockets adjoining the abdomen) of midges in the wild are known to be filled with fungal spores that are thought to be inserted with the eggs at oviposition. In the newly emerged midges examined in this study, no spores were seen in the mycangia. Spores of *Alternaria* sp. were seen on the surfaces of 15% of the midges emerging from *Borrichia frutescens* galls ($n = 60$); 10% of the midges from *Iva imbricata* (n=20); and 40% of these midges from *I. frutescens* ($n = 5$). Limited observations of several epidermal peels from plants of *B. frutescens* revealed that *Alternaria* sp. and *Fusarium* sp. were abundant on the plant surface. While it may be possible for the midges to carry fungal spores at oviposition, it seems that the diversity of fungi seen in these midge galls and host plant tissue are sourced by other means, possibly including some of their parasitoids.

We observed that fungal endophytes appear to become denser in the plant tissues between May (seen in the preliminary study) and September revealing increasing hyphae and pigmentation (Fig. 2). The aging galls in this study were seen to include fungal contents that became denser and darker with pigments (Fig. 1). *Alternaria* sp. and *Bipolaris* sp., both darkly pigmented, were consistently

TABLE 2. Percent occurrence of fungi isolated from apical, stem and leaf tissues isolated from *Borrichia frutescens*: galled and non-galled plants.

	Merritt Island		Mayport		Ft Desoto	
	gall	non-gall	gall	non-gall	gall	non-gall
Sterile mycelia						
Apex	33.3	–	66.7	13.3	40	
Stem	33.3	20	26.7	20		
Leaf	6.7	26.7	13.3	6.7	40	
Alternaria sp.						
Apex		13.3			13.3	
Stem	6.7					
Leaf	20	6.7	33.3	6.7		13.3
Verticillium lecanii (A. Zimmerm.) Viégas						
Apex	–	–	–	–	–	-
Stem	–	–	6.7		–	–
Leaf	–	20	–	–	20	–
Bipolaris sp.						
Apex	–	–		–	–	
Stem	6.7	–		–	–	–
Leaf		6.7			–	
Acremonium strictum W. Gams						
Apex	–	–	–			–
Stem	13.3	–	20	–	–	–
Leaf	–	–	–	–	–	–
Humicola grisea Traaen						
Apex	–	–	–	–	–	–
Stem	–	–	–	–	6.7	–
Leaf	–	–	–	–	–	
Monocillium indicum S.B. Saksena						
Apex	–	–		–		
Stem	–	–		–	6.7	–
Leaf	–		–	–	–	–
Penicillium sp.						
Apex				6.7		
Stem						
Leaf	-		–	–		
Fusarium sp.						
Apex	–	–	–	–	–	–
Stem	6.7	–	–	–	–	–
Leaf	–	–	-	–	–	–

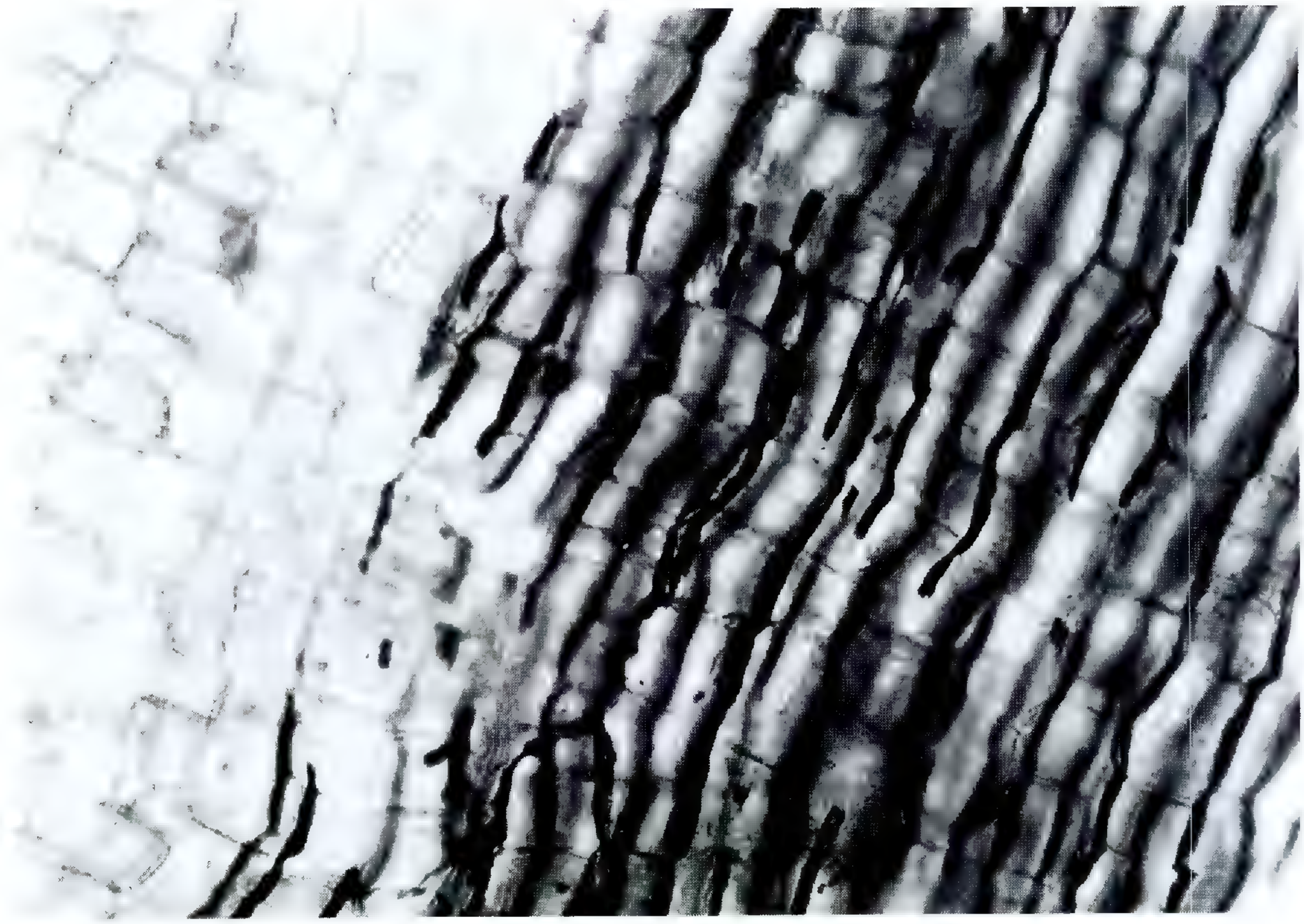


FIG. 2. *Borrichia frutescens*. Hyphae of endophytes in stem pith tissue.

isolated from galled and non-galled plant tissue. Shaw (1992) reviewed several studies indicating that fungivores consistently favored darkly pigmented litter fungi. Interestingly, it seems that *Alternaria* sp. and *Bipolaris* sp. could play a nutritional role in this gall system.

In this study we establish the presence of entophytic fungi in insect galls. Endophytic fungi were cultured from tissues of galled and non-galled plants of *Borrichia frutescens*. Both of these plant types carry several fungal taxa. These observations are common to all sites, but sample sizes are too limited to discern major differences. Fungal spores were directly observed on 15% of examined midges. This suggests that the midges may play a role in fungal dispersal to gall tissue as proposed by Batra and Lichtwardt (1963).

ACKNOWLEDGMENTS

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Book Review

Eugene N. Kozloff. 2005. **Plants of Western Oregon, Washington & British Columbia. (ISBN 0-88192-724-4, hbk.).** Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax.). $65.00, 608 pp., 712 color photos, 354 b/w line drawings, 7 3/8" × 10 3/8".

"This new book, using a relatively small vocabulary of scientific terms, is designed for the identification of vascular plants ... that grow west of the crest of the Cascades, from southern Oregon north through southern British Columbia. It is also very useful on the higher portions of the slopes east of the crest of the Cascades." More than 2500 species are included—354 line drawings (interspersed through the text, mostly by Jeanne Janish and John Rumely from Vascular Plants of the Pacific Northwest) and 709 excellent color photos (arranged together in the middle of the book). A brief discussion is provided for each family, followed by a key to genera, then by keys to the species of each genus. All morphological and distributional information is conveyed in the keys. All taxa are alphabetically arranged, without authorities and publication details; common names are provided but scientific synonymy is minimal. The species coverage and nomenclature is much updated from predecessors, but concepts of families and genera remain conservative. For example, in the Asteraceae, groups of similar species are keyed in conglomerates (*Balsamorhiza-Wyethia* complex, *Aster-Machaeranthera* complex, *Ericameria-Pyrrocoma-Columbiadoria-Hazardia* complex, *Solidago Euthamia* complex, *Madia-Anisocarpus-Hemizonella-Kyhosia* complex). The user-friendly keys, the heart and soul of this volume, appear to be effective and Kozloff's book undoubtedly will quickly find its way into wide use.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

TYPE LOCALITIES OF VASCULAR PLANTS FIRST DESCRIBED FROM OHIO: SUPPLEMENT[1]

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In 2003 Ronald L. Stuckey and I published a list of Ohio localities at which the type specimens of the names of vascular plants had been obtained, including the plant names based on specimens from each locality. Omissions have become apparent, hence this supplement. As in the original list, double asterisks denote names that are currently accepted for the respective taxa. Otherwise, the currently accepted names are given in brackets. Minor variants not otherwise accounted for are now generally not recognized taxonomically, but remain included within the same species. Further explanation of the format appears in our earlier paper.

OHIO

Carex xanthocarpa E.P.Bicknell, Bull. Torrey Bot. Club 23:22. 1896, not Degl. 1807; *C. vulpinoidea* var. *xanthocarpa* Kük., Pflanzenr. (Engler) 4(20, heft 38):148. 1909, based on *C. xanthocarpa* E.P.Bicknell; *C. bicknellii* E.G.Camus, Notul. Syst. (Paris) 1:239. 1910 and *C. brachyglossa* Mack., Bull. Torrey Bot. Club 50:355. 1923, both published in substitution for *C. xanthocarpa* E.P.Bicknell [*Carex annectens* (E.P.Bicknell) E.P.Bicknell].

Laciniaria shortii Alexander ex Small, Man. S.E. Fl. 1335. 1933 [*Liatris squarrulosa* Michx.].

Vernonia maxima Small, Bull. Torrey Bot. Club 27:280. 1900 [*Vernonia gigantea* (Walt.) Trel. var. *gigantea*].

Maumee River

Baptisia leucantha Torr. & A. Gray, Fl. N. Amer. 1:385. 1840 [*Baptisia alba* var. *macrophylla* (Larisey) Isely].

Miami River, Miami Country

Geum franckii [sic] Steud., Nomencl. Bot., ed. 2, 1:683. 1840, not Sm. 1810; published in substitution for *Geum parviflorum* Hochst. & Steud., that name not validly published [*Geum vernum* (Raf.) Torr. & A. Gray].

[1]Contribution No. 128 from the Royal Botanical Gardens, Hamilton, Ontario, Canada.

Franklin County

Columbus. **Trillium erectum** var. **declinatum** A. Gray, Man., ed 5, 523. 1867; *T. declinatum* (A. Gray) Gleason, Bull. Torrey Bot. Club 33:389. 1906, not Raf. 1840, and *T. gleasonii* Fernald, Rhodora 34:21. 1932, published in substitution for *T. declinatum* (A. Gray) Gleason [*Trillium flexipes* Raf.].

Hamilton County

Cincinnati. **Aira controversa** Steud., Syn. Fl. Glumac. 1:224. 1854 [*Sphenopholis intermedia* (Rydb.) Rydb.].

Crataegus coccinea [var.] ϵ? [sic] **mollis** Torr. & A. Gray, Fl. N. Amer. 1:465. 1840 [*Crataegus coccinea* L., not *Crataegus mollis* Scheele].

Lippia nodiflora var. **acutifolia** Kuntze, Revis. Gen. Pl. 2:508. 1891 [*Phyla nodiflora* (L.) Greene; often retained in *Lippia*].

Stachys cincinnatensis Kuntze, Revis. Gen. Pl. 2:521. 1891 [*Stachys tenuifolia* Willd.].

Volvulus sepium var. **biangulo-sagittatus** [sic] Kuntze, Revis. Gen. Pl. 2:447. 1891 [*Calystegia sepium* (L.) R.Br. subsp. *angulata* Brummitt].

Cincinnati, Lawrence Bay. **Sida spinosa** var. **flava** Kuntze, Revis. Gen. Pl. 1:73. 1891.

Lawrenceburg. **Iriha** [sic] **autumnalis** var. **caespitosa** Kuntze, Rev. 2:752. 1891 [*Fimbristylis autumnalis* (L.) Roem. & Schult.].

Hocking County

Cedar Falls. **Vittaria appalachiana** Farrar & Mickel, Amer. Fern J. 81:69. 1991.

Lorain County

North Amherst. **Geranium carolinianum** var. **confertiflorum** Fernald, Rhodora 37:300. 1935 [*Geranium carolinianum* L. var. *carolinianum*].

Lucas County

Alexis [interpreted as the railroad junction in present-day Toledo rather than the community in Monroe County]. **Cardamine douglasii** forma **albidula** Farw., Amer. Midl. Nat. 9:261. 1925.

Toledo, Maumee River bank, Walbridge Park. **Malus coronaria** var. **dasycalyx** Rehd., J. Arnold Arbor. 2:52. 1920.

Meigs County

Slope above Leading Creek, Co. Rt. 10, 0.25 mi SW of Twp. Rt. 27, N of Dexter, Sect. 6, Salem Twp. **Polypodium × incognitum** Cusick, Amer. Fern J. 92:241. 2002 [= *Polypodium appalachianum* Haufler & Windham × *P. virginianum* L.].

Richland County

Mansfield. **Convolvulus sepium** var. **communis** R.M.Tryon, Rhodora 41:419. 1939 [*Calystegia sepium* (L.) R.Br. subsp. *sepium*].

Scioto County

Friendship, Shawnee State Forest, Camp Gordon C.C.C. **Disporum schaffneri** Moldenke, Phytologia 1:167. 1935 [*Prosartes maculata* (Buckley) A. Gray].

In addition, the names ***Oxalis grandis* Small, based on *O. recurva* Elliott sensu Trelease, not as originally applied by Elliott, and ***Sanicula trifoliata* E.P.Bicknell were originally based on syntypes that included specimens respectively from "Ohio" and "Franklin County, Ohio." *Elymus canadensis* var. *intermedia* Vasey ex S.Watson & J.M.Coult. was originally described with no specimens cited but with the range said to include Ohio [now included in *E. virginicus* L. var. *virginicus*]. For all of these mames later authors have designated specimens from other states as the lectotypes.

REFERENCE

Stuckey, R.L. and J.S. Pringle. 2003. Type localities of vascular plants first described from Ohio. Sida 20:1677–1692.

Book Notice

Peter Gregory. 2006. **Plant Roots: Growth Activity and Interaction With Soils**. (ISBN 1-4051-1906-3; 978-1-4051-1906-1, hbk.). Blackwell Publishing Professional, 2121 State Street, Ames, IA 50014-8300, U.S.A. (**Orders:** www.blackwellplantsci.com, 800-862-6657, 515-292-3348 fax). $199.99 hbk., 328 pp., illustrations, 7" × 10".

As suggested by the cover notes, "this book will be a vital tool for plant, crop, soil, and agricultural scientists, plant physiologists, environmental scientists, ecologists, and hydrologists." It's expensive, but perhaps "essential" as well as "vital." There are nine chapters, densely packed with technical information but easily readable, as follow.

1. Plants, Roots and the Soil (evolution, roots and shoots, roots and soil).
2. Roots and the Architecture of Root Systems (structure, extension and branching, root tip, system architecture).
3. Development and Growth of Root Systems (measurement of root systems, system development, size, and distribution, longevity and turnover, modelling).
4. The Functioning Root System (anchorage, water and nutrient uptake).
5. Roots and the Physico-chemical Environment (temperature, tropistic responses, soil pores and mechanical properties, atmospheric CO2).
6. Roots and the Biological Environment (soil organisms, symbioses, pathogens and parasites, root herbivory).
7. The Rhizosphere (rhizodeposition, chemical changes affecting nutrient acquisition, physical changes in the rhizosphere).
8. Genetic Control of Root System Properties (genotypic differences, genetics, breeding).
9. Root Systems as Management Tools (optimal root systems, intercropping and agroforestry, crop rotations, phytoremediation).

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NOTES ON SOUTHWESTERN MORACEAE

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ABSTRACT

Specimens forming the basis of reports of *Ficus palmata* (*F. pseudo-carica*) in North America are misidentified and actually belong to *F. carica*, so *F. palmata* must be excluded from the adventive flora of North America. *Morus nigra* is present as a rare waif in California and Nevada. It is best distinguished from other *Morus* species in the area by its deeply cordate leaves and densely pubescent styles 3–5 mm long.

RESUMEN

Los especimenes en que se basan las citas de *Ficus palmata* (*F. pseudo-carica*) en Norte América están mal identificados y pertenecen a *F. carica*, por lo que *F. palmata* debe excluirse de la flora adventicia de Norte América. *Morus nigra* está presente como una planta rara abandonada en California y Nevada. Se diferencia de otras especies de *Morus* en el área por sus hojas profundamente cordadas y estilos densamente pubescentes de 3–5 mm de longitud.

Moraceae are primarily trees and shrubs of tropical and subtropical areas, with few herbaceous species and few taxa found in areas with cooler climates. The family is poorly represented in the flora of the southwestern United States: recent floras list only two native species, *Morus microphylla* Buckl. (which occurs from central Texas west to Arizona and across northern Mexico) and *M. rubra* L. (an eastern species that crosses the Great Plains in Texas), and three introduced species, *M. alba* L., *Ficus carica* L., and *Maclura pomifera* (Raf.) Schneid., from the western half of the country (McClintock 1993; Wunderlin 1997). Two other exotic species not mentioned in these floras, *Ficus palmata* Forrsk. and *Morus nigra* L., have been recorded as escapes in California and Nevada. In the course of revising McClintock's treatment for the second edition of the *Jepson manual of the higher plants of California*, specimens vouchering these reports were examined in order to clarify the status of these species as possible escapes in North America.

California reports of *Ficus palmata*

Ficus palmata is a small tree or shrub native from Iran east to India and Nepal, and south to Ethiopia and Somalia. It is closely related to the commercial fig, *Ficus carica* L., a native of the Near East that is now naturalized at scattered sites across much of the southern United States (Wunderlin 1997), but *F. palmata* differs in having smaller, often unlobed, leaves and smaller fruit (Browicz 1982; Friis 1993; Ghafoor 1985). *Ficus palmata* (=*F. pseudo-carica* Miq.) has been re-

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ported from southern California, first by Munz (1974). Munz used the newer synonym *F. pseudo-carica* Miq. and described it as similar to *F. carica*, but with leaves more deeply divided, a description that is at odds with descriptions and keys in recent floras of areas where *F. palmata* is native (Browicz 1982; Friis 1993; Ghafoor 1985). Munz listed the species as "Reported as occasional escape in Santa Barbara region," the phrasing suggesting that Munz picked up his identification from another source. Smith (1976, 1998) mentioned two collections by Henry M. Pollard from "west fork of Cold Springs [sic] Canyon, Montecito." The species was not treated for California in the most recent state flora (McClintock 1993) or the *Flora of North America* (Wunderlin 1997), but it was reported again (this time under the older name *F. palmata*) by Hrusa et al. (2002), who cited a single collection from Santa Barbara County, California, made by Henry Pollard in 1958.

In view of the irregular treatment of this species (reported by several local floras, but not the most recent state and national floras) and the mismatch between the keys and descriptions of *F. palmata* in the North American and Old World literature, it seemed best to examine the specimens that the California reports are based on and compare them with specimens collected from the native range of *F. palmata* in the Old World, as well as the full range of variation in cultivated *F. carica*.

Variation in *Ficus palmata* and *F. carica*

Thirty-one specimens from three herbaria (MO, NA, and US), representing *Ficus palmata* from throughout its native range, were examined and coded for morphological characters that potentially distinguish the species from *F. carica*. The results are shown in Table 1, along with characters of cultivated *F. carica*, taken from 70 sheets of cultivated figs, and characters of the vouchers for the California reports of *F. palmata* (see below). Characters taken from herbarium specimens agree well with descriptions and illustrations of the two species from standard sources (Browicz 1982; Condit 1947; Friis 1993; Ghafoor 1985).

Representative specimens examined: *Ficus palmata*. **INDIA:** Botanical Garden, University of Delhi, *Rodin 8049* (US). Setabani, *Hem Raj s.n.* 28 Feb 1931 (MO). Koraput district, Jaypore Estate, Orissa, 3000–3500 ft, *H.F. Mooney 3893* (MO). Deopal, Garhwal, *W. Koelz 20496* (NA). Almora, United Provinces, 6000 ft, *W. Koelz 19996* (NA). **PAKISTAN:** Peshawar, *W. Koelz 8206* (NA); 3 mi from Abbotabad on road to Havelion, *M. Qaiser & A. Ghafoor 1999* (NA); Karakar, *M. Shah & Dilawar 1001* (MO). **NEPAL:** Wada, 6600 ft, *Mr. Hoh and Rajbhandari 1157* (US). **SAUDI ARABIA:** Al Karn, *Dwyer & El Sheikh 13676* (MO). **YEMEN:** Attara, 1900 m, *Deflers 402* (US). **ERITREA. Amasen:** Ad Rassi, *Pappi 4925* (US). **ETHIOPIA. Kaffa Prov.:** 7 km E of Jimma, *Burger 1158, Meyer 7820* (US). **Harar Prov.:** 22 km SE of Harar, ca. 1350 m, *Burger 1158, 1622* (US).

Ficus carica (all cultivated, all deposited at NA). **CHILE. Juan Fernandez Islands:** Mas Afuera, *F.G. Meyer 9461*. **IRAN.** Tehran, *W. Koelz 16085*. **U.S.A. Arkansas. Drew Co.:** Monticello, *E. Sundell 9111*. **California. Alameda Co.:** Niles, *J. Jones 23041*. **Butte Co.:** Chico, *W.F. Wight 1279*. **Riverside Co.:** Citrus Experiment Station, Riverside, *I.J. Condit 1*. **Santa Barbara Co.:** Franceschi Nursery, Santa Barbara, *W.F. Wight 4879*. **Sonoma Co.:** Sonoma, *H. Grinstead s.n.* 4 Jun 1978. **Florida. Alachua Co.:** Gainesville,

F.G. Meyer & P.M. Mazzeo 14365. **Georgia. Morgan Co.:** Madison, *F.G. Meyer & P.M. Mazzeo 20440.* **Illinois. Cook Co.:** Morton Arboretum, Lisle, *N. Gavlak 4098V90.* **South Carolina:** Columbia, *J.B. Nelson 19580.* **ZIMBABWE:** Salisbury, *H. M. Bigel 4444.*

California material referred to *Ficus palmata*

The collections cited as *Ficus palmata* and *F. pseudo-carica* by Smith (1976) and Hrusa et al. (2002) are part of a series of four collections made by Henry Pollard (*Pollard s n.* 20 November 1955, 29 September 1956, 23 December 1958, and 28 November 1959 [all CAS]). All bear the same locality data (bed of west fork of Cold Spring Canyon, Santa Barbara Co.) and evidently came from the same colony (perhaps the same plant), described by Pollard on the herbarium labels as a clump of tall, suckering stems growing among boulders in the streambed. The plant was evidently immature when Pollard first collected it, and he revisited it several times to get more mature material. The first three specimens (1955, 1956, and 1958) are all sterile, and the 1956 label specifically describes the plants as "Adventive seedlings," while the 1959 collection is the only fertile specimen in the series, and the label says: "Largest shoots, heretofore sterile, beginning to bear fruit." The 1955 collection was annotated, apparently in Pollard's handwriting, as *F. carica*; the others were named "*Ficus pseudo-carica* Miq.?," all three with the question mark.

Morphological characters of these specimens are given in Table 1.

RESULTS

The Pollard collections from Cold Spring Canyon match *F. carica*, not *F. palmata*, in most of their characters (the thickness and dark coloration of the twigs, the large, deeply lobed leaves with obtuse or acute apices, strongly cordate bases, and shallowly crenate margins, and the turbinate fruit). Only the density of the indumentum on the twigs and petioles is in any way unusual for *F. carica*, and this character is rather variable in *F. carica*. The indumentum is dense only in the earlier Cold Spring Canyon collections (1955 and 1956, made when the plants were quite immature); later collections, made as they approached and reached sexual maturity (1958 and 1959), show sparser indumentum, within the normal range of variation of *F. carica*. The plant collected by Pollard and reported by several authors as *F. pseudo-carica* or *F. palmata* is clearly *F. carica*; the unusual indumentum characters may be related to juvenility. Specimens of *F. palmata* have occasionally been grown horticulturally in the United States (*W.F. Wight 4870*, Franceschi nursery, Santa Barbara California, NA), but there is no evidence that the species has ever escaped from cultivation. It should be excluded from the adventive flora of North America.

Morus nigra in the southwest

Black mulberry (*Morus nigra*) is a small tree native to the mountains of southwest Asia (probably Iran and the Caucasus). It is a very old cultigen—mulberry

TABLE 1. Comparison of morphological characters of Asian *Ficus palmata*, cultivated *F. carica*, and California specimens forming the basis of the North American reports of *F. palmata*. The last column notes for each morphological character which species is the best match for the California specimens.

	Ficus palmata	***Ficus carica***	**Basis of CA *F. palmata* report**	
Material coded	31 sheets from India, Nepal, Pakistan, Saudi Arabia, Yemen, Eritrea and Ethiopia	ca. 70 sheets, cultivated worldwide	4 Pollard collections, W fork Cold Spring Canyon, Santa Barbara Co., CA	Best match for Pollard figs
Twig color	tan or brown, sometimes, greenish, usually with a ± ashy cast from the white indumentum	brown, usually dark	purplish brown	*F. carica*
Twig diameter mm	1.5–4	4–5	4–6	*F. carica*
Twig indumentum	moderately to densely hirsute	glabrous or sparsely hirsute	sparsely to moderately hirsute	intermediate
Petiole length mm	16–70	40–119	110–125	*F. carica*
Petiole indumentum	sparsely to densely hirsute, seldom puberulent	glabrous or sparsely hirsute	sparsely to moderately hirsute	*F. palmata*
Blade length mm	57–142	114–211	240–320	*F. carica*
Blade width mm	50–140	129–210	240–370	*F. carica*
Blade shape	ovate to triangular	ovate to very broadly ovate in outline	ovate to very broadly ovate in outline	either
Blade lobing	usually unlobed, seldom 3(–5)-lobed to 0.4(–0.7) of length	3–5-lobed 0.5–0.85 of length (rarely shallowly lobed)	5-lobed 0.75–0.8 of length	*F. carica*
Blade/lobe margin	shallowly to strongly crenate-toothed or bluntly toothed	crenate or irregularly wavy	crenate	*F. carica*
Blade base	broadly obtuse to truncate or shallowly cordate	shallowly to deeply cordate, rarely broadly obtuse	cordate	*F. carica*
Blade apex	rounded, apiculate or acuminate	rounded or obtuse, very rarely acute but never acuminate	obtuse or acute	*F. carica*
Fruit shape	globose, often from a linear stipe-like base	turbinate	turbinate	*F. carica*
Fruit width mm	9–15 mm	more than 15 mm	too immature to measure	—

seeds are known from early archaeological sites in Mesopotamia and Egypt (Brothwell & Brothwell 1969)—and black mulberry is now widespread in central and western Asia and the Mediterranean basin. In the North American botanical literature, the name *M. nigra* has been confused since Small (1903, 1933) misapplied it to dark-fruited forms of *M. alba*, an east Asian species that is widely naturalized in the United States (Wunderlin 1997). Wunderlin's discussion seems to suggest that the two taxa may be conspecific, but *M. alba* and *M. nigra* are actually quite distinct, differing (among other features) in their chromosome numbers, *M. alba* being diploid with $2n=28$ while a variety of polyploid or high aneuploid numbers, varying from $2n= 89$-308, have been reported for *M. nigra* (Voltattorni 1947; Darlington & Wylie 1955; Hans 1972).

Morus nigra was reported to escape occasionally in Beatty Townsite, Nye Co., Nevada, by Beatley (1976). This report has not been mentioned in subsequent publications, including the Flora of North America Moraceae treatment (Wunderlin 1997). A check of Beatley's vouchers showed that they are correctly determined and also revealed specimens of apparent waifs collected by Henry M. Pollard at a site in southern California (see below for specimen data). These collections indicate that black mulberry is able to reproduce as a waif at widely separated sites in the southwestern United States. It is only known as a waif in disturbed areas close to settlements, and there is no evidence that it can persist for long periods or disperse into intact natural vegetation. The species is not correctly described or keyed in any North American flora (except McMinn & Maino 1947, who included it as a cultivated species), so a brief description of *M. nigra* and an emended key for the region are provided. In order to enlarge the sample size and capture the normal range of variation in the species, the description below was supplemented with cultivated material from the southwestern United States. Illustrations of *M. nigra* are provided by McMinn and Maino (1947, fig. 203) and Browicz (1982, fig. 1).

KEY TO SPECIES OF *MORUS* IN THE WESTERN UNITED STATES

1. Leaves reniform-triangular to almost circular, base deeply cordate. Styles 3–5 mm long, densely hairy all over. Syncarp purple-black or black _____ **M. nigra**
1. Leaves ovate or triangular-ovate, base rounded, truncate, or shallowly cordate. Styles 1–2 mm long, glabrous (rarely with a few hairs). Syncarp red, purple, or white.
   2. Upper surface of leaf smooth, often very shiny, glabrous or with a few hairs on the main veins; underside glabrous except for scattered hairs on the major veins or in vein axils. Syncarp short-cylindrical to almost spherical, 0.6–1.8 × 0.5–0.7 cm _____ **M. alba**
   2. Upper surface of leaf dull, often scabrous, with hairs (very inconspicuous in *M. rubra*) evenly scattered over the blade; underside pubescent with hairs evenly scattered over the veins and blade. Syncarp various.
      3. Trees to 20 m tall. Leaves ovate to subcordate or almost circular, 7–28 × 7–25 cm, if lobed then lateral lobes abruptly acuminate. Syncarp short-cylindrical, 1–1.9 × 0.6–0.8 cm _____ **M. rubra**

3. Low shrubs to small trees 2–5 m tall. Leaves ovate or triangular-ovate, 2.8–8.3 × 1.6–5.3 cm, apex abruptly acuminate, if lobed then lateral lobes acute, obtuse, or occasionally rounded. Syncarp more or less spherical, 0.5–1.2 × 0.6–1.3 cm _____ **M. microphylla**

Morus nigra L., Sp. Pl. 2:986. 1753. Black mulberry

Small trees 3–5 m tall. Twigs brown, 2–4 mm thick, puberulent, pilose, or glabrous; buds ovoid, 5–7 mm long. Petiole 1.2–3.0 cm long, pubescent with long soft hairs, at least ventrally. Blade reniform-triangular to almost circular, unlobed or rarely 3-lobed, 7–16 cm long and wide, (3–)5-veined from base; base deeply cordate, apex abruptly short-acuminate, margins dentate, teeth rounded-obtuse, 2–5 mm long; upper surface green, smooth or very weakly scabrous, glabrous or with a few scattered hairs mostly confined to the major veins; underside lighter green, soft-pubescent on veins and blade. Unisexual. Styles 3–5 mm long, densely hairy all over. Fruiting peduncle densely pubescent; syncarp short-cylindrical, 1.4–2.2 cm long, 1.0–1.6 cm wide, purple-black or black.

Specimens examined. **U.S.A. NEVADA. Nye Co.:** apparently escaped, in thicket with Screw-bean, Beatty townsite, Amargosa drainage, 3300 ft, U.S.A. E.C.'s Nevada Test Site, *J. Beatley 13438* (US). **CALIFORNIA. Ventura Co.:** two small trees in low waste ground in dense brake of *Rubus procerus*, S of railroad and Fox St. drain, Ojai, origin unknown, location suggesting escape from cultivation, *H.M. Pollard s.n.*, 21 Oct 1965 (NA); same locality, *H.M. Pollard s.n.*, 20 Jun 1968 (NA).

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Book Review

Chet van Duzer. 2004. **Floating Islands: A global bibliography with an Edition and Translation of G. C. Munz's Exertacio academica de insulis natantibus (1711).** (ISBN 0-9755424-0-0, hbk.). Cantor Press, Los Altos Hills, California 94024, U.S.A. (**Orders:** www.cantorpress.com). $44.95, 400 pp., illustrated, 6 1/8" × 9".

To an average versed and educated reader the word floating island evokes association to Jules Verne and Jonathan Swift, to the description of explorations of swamps along the upper course of the Nile River and to the floating gardens of the Titicaca Lake. These do not seem entirely concrete objects existing in the everyday life. This is the case in most countries without such islands. *Floating Islands* is an extensive and exciting annotated review of 2500 years of publications on floating islands, covering all possible items from floating bogs to pumice islands and from bird nest rafts to floating airports.

Van Duzer's book consists of two main parts. The first (33 pp.) is a reprint of the full Latin text and English translation of Georgius Christophorus Munz's rare 1711 *Exercitatio academica de Insulis natantibus*. Thus the basic work on the topic is easily accessible to the reader, both in its original form as well as its translation. Comprehensive and clear notes by Van Duzer follow (pp. 35–67) the Munz's description. The second part of the book is Global Bibliography on Floating Islands. On 280 pages there are gathered more than 1800 references of books and articles in twenty languages treating this subject. The entries are annotated and cross-referenced, and there are both thematic and geographic indices. All aspects of floating islands are addressed, including the formation of floating islands, the causes of their buoyancy, their role in the ecology of lakes and wetlands, their flora and fauna, their role in the dispersal of plants and animals, and methods for controlling and managing them. Works are also cited on artificial floating islands used for agriculture, human habitation, wildlife habitat, and improvement of water quality; and floating islands in literature, myth, and legend. The book includes the text and an English translation, with detailed notes, of G.C. Munz's rare 1711 thesis on floating islands, *Exercitatio academica de insulis natantibus*, as well as photographs of several floating islands.

Van Duzer's book is not only a complete (or one of the most) bibliography on floating islands, but also an indispensable source of literature for everyone wishing to know different aspects of floating islands. *Floating Islands* succeeds in condensing a large body of historical observation and thought; in addition, it contains summaries of the recent research on floating wetlands. Essentially every feature of floating islands is examined—their formation, causes of their buoyancy, dominant flora and fauna, and their interactions with the wetland, lake, and river habitats with which they are associated. The comprehensive coverage extends to artificial floating islands, to their uses, including human habitation, and into classical literature and mythology.

Van Duzer has not only provided a masterful treatment of the subject but has also provided an excellent bibliography. *Floating Islands* should serve as a basis for great scholarship for years to come. Recommended for all academic, botanical, herbarium, and taxonomic libraries. Larger public libraries would be well advised to include it in their collection.—*Gary Jennings, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

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EXOTIC PLANT INTRODUCTION IN KANSAS, TWO NEW SPECIES

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ABSTRACT

Described in this paper are two new records for Kansas, *Myagrum perfoliatum* L. (Brassicaceae) and *Lespedeza thunbergii* (DC.) Nakai (Fabaceae), with details about their local introduction and establishment.

RESUMEN

Se aportan dos nuevas citas para Kansas, *Myagrum perfoliatum* L. (Brassicaceae) y *Lespedeza thunbergii* (DC.) Nakai (Fabaceae), con detalles de su introducción local y establecimiento.

Myagrum perfoliatum (Brassicaceae) was discovered in the ranch cattle pens south of the barn at Tallgrass Prairie National Preserve in Chase County, Kansas by Dillis Owen, National Park Service employee, in June of 2000. Plants were 1 m tall and almost as wide. There were no leaves remaining on the plants when they were found. The distinctive fruits are club-shaped and 5–7 mm long. The primary associated species in the corrals at the time were *Rumex*, *Amaranthus*, and *Conium maculatum*.

There are no other mustards growing in Kansas that could be confused easily with *M. perfoliatum*.

Voucher specimen cited: **KANSAS. Chase Co.:** Tallgrass Prairie National Preserve, a few plants in the cattle pens near the barn, 10 Jun 2000, *Dillis Owen s.n.* (KSC).

Myagrum perfoliatum is native to Europe and western Asia. Exactly when it arrived in North America is uncertain, but it most likely came as a crop weed. This species is currently recorded from Texas, Oklahoma, and Ohio (USDA 2005). In the Texas counties of Dallas, Delta, Denton, Frannin, Grayson, Johnson, and Rockwall it is described as abundant and spreading (Diggs et al. 1999).

Cattle delivered to Tallgrass Prairie National Preserve are frequently shipped from Texas, so it is presumed that introduction of *M. perfoliatum* came from seed carried in the hooves, hair, or manure of livestock, or possibly on trucks when the animals were unloaded at the ranch corrals.

When *M. perfoliatum* was first found at Tallgrass Prairie National Preserve, the plants were mature and had produced seeds. Subsequent search of the corrals revealed five locations, mostly along fences or along building perimeters, where *M. perfoliatum* was growing. The species persisted, and large, seed-pro-

ducing plants were collected again the following year in areas where they were missed by mowing.

Intervening floristic surveys at Tallgrass Prairie National Preserve resulted in the discovery of no other populations on the ranch. Hand pulling, herbicide spraying, and mowing in the cattle pens have been effective in controlling this weedy annual. In 2004 and 2005 no *M. perfoliatum* was found in the corrals at Tallgrass Prairie National Preserve. Monitoring of the cattle pens for *M. perfoliatum* will continue.

Lespedeza thunbergii (Fabaceae) is native to eastern Asia and has naturalized in the eastern two-fifths of North America (Kartesz 1999, USDA 2005). In September 2005, *L. thunbergii* was found growing in sand prairie at Maxwell Wildlife Refuge in McPherson County, Kansas. The refuge is owned and operated by Kansas Department of Wildlife and Parks. Manager, Cliff Peterson, recalls that at one time a 3-row shelter belt ran east and west along the fence line, and *L. thunbergii* was planted in the north row of the shelter belt. The entire shelter belt and some of the fence has since been removed, but a population of *L. thunbergii* remains in ungrazed native prairie.

During the same period that maintenance of the shelter belt was discontinued, refuge policy regarding prescribed burning changed. Beginning in 1978, fire was no longer totally suppressed as it had been for more than 30 years, and a third-year burning regime was initiated to reduce woody shrubs. This leads to interesting questions about the persistence of *L. thunbergii* at the refuge, since rather than inhibit shrub lespedezas, including *L. thunbergii*, fire favors them by encouraging seed germination (Maryland Cooperative Extension Service 2005).

Lespedeza thunbergii plants at the refuge are 1–1.8 m tall and grow in open, sandy soil among prairie grasses and forbs. They form a thicket approximately 60 m^2 in a slight draw. Individuals are scattered a short distance from the main population. Multiple, semi-woody stems originate from the base of each plant. The rose-purple corolla is 13–15 mm long, leaflets are 2–3 times as long as wide and acute at the apex. The plants produced an abundance of seeds.

The only other *Lespedeza* that might be mistaken for *L. thunbergii* is *L. bicolor*. *Lespedeza bicolor* has been found at only one or two locations in Kansas and differs by having a shorter corolla and rounder leaflets (Isely 1990).

Voucher specimen cited: **KANSAS. McPherson Co.:** 5 mi S, 1 mi W of Roxbury, SE of tower at Maxwell Wildlife Refuge in sandy prairie, 26 Sep 2005, *Barnard 2086, C. Peterson* (KSC).

Lespedeza thunbergii is grown in the United States as an ornamental and is recommended for wildlife food and cover. The Maryland Cooperative Extension Service has published the uses, establishment, and management of several shrub lespedeza species, including *L. thunbergii* (Maryland Cooperative Extension Service 2005). The Southeast Exotic Pest Plant Council lists *L. thunbergii*

as level three on the Kentucky invasive plant list. Level three is regarded as a "lesser threat" and described as a species that principally spreads and remains in disturbed corridors, not readily invading natural areas (SE-EPPC 2005). Concern about the invasive tendencies of related species, *L. cuneata*, in Kansas has persuaded refuge management in McPherson County to consider control or eradication of *L. thunbergii*.

ACKNOWLEDGMENTS

Specimens of both of these species are deposited at the Kansas State University Herbarium (KSC) in Manhattan, Kansas. I am grateful to Tallgrass Prairie National Preserve personnel for assistance, to Cliff Peterson for allowing permission to collect at Maxwell Wildlife Refuge, and to Caleb Morse for input regarding KANU specimens. Thanks also to Craig Freeman and one anonymous reviewer for helpful suggestions.

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Book Notice

Pamela A. Matson, Ashok Gadgil, and Daniel M.Kammen (eds). 2005. **Annual Review of Environment and Resources: Volume 30, 2005**. (ISBN 0-8243-2330-0, hbk; ISSN 1543-5938). Annual Reviews Inc., 4139 El Camino Way, P.O. Box 10139, Palo Alto, CA 94303-0139, U.S.A. (**Orders:** www.AnnualReviews.org, 800-523-8635, 650-493-4400, 650-424-0910 fax). $191.00, 648 pp., 6" × 9".

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NEW AND DISJUNCT RECORDS OF *ELEOCHARIS LIESNERI* (CYPERACEAE) FROM SOUTH AMERICA

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ABSTRACT

Eleocharis liesneri is reported here for the first time from Brazil and Colombia. These newly discovered specimens represent the only collections known besides the type of the species, and suggest that this taxon might have a peri-Amazonian distribution. A detailed description, key, and illustration to aid in separation of *E. liesneri* from other South American species of *Eleocharis* subg. *Limnochloa* with which it has been confused are provided.

RESUMEN

Eleocharis liesneri se cita aquí por primera vez de Brasil y Colombia. Estos especimenes representan las únicas recolecciones conocidas aparte del tipo de la especie, y sugieren que este taxon pudiera tener una distribución periamazónica. Se ofrece una descripción detallada, una clave, e ilustración para ayudar en la separación de *E. liesneri* de otras especies suramericanas de *Eleocharis* subg. *Limnochloa* con las que ha sido confundido.

Eleocharis R. Br. is a cosmopolitan genus of about 200 species and 600 published names with a concentration of taxa in tropical America (González-Elizondo & Tena-Flores 2000). *Eleocharis* subg. *Limnochloa* (P. Beauv. ex Lestib.) Torr. (= *Eleocharis* ser. *Mutatae* Svenson) is distinguished from other *Eleocharis* by a combination of usually cartilaginous to indurate, obscurely keeled, many-veined floral scales, coarse culms (often as thick as the spikelet) and biconvex (rarely trigonous) achenes usually conspicuously sculptured with polygonal cells (González-Elizondo & Peterson 1997).

During examination of specimens for a systematic study of *Eleocharis* subg. *Limnochloa*, I discovered a collection from the State of Mato Grosso, Brazil, that was identified as *E. fistulosa* (Poir.) Link, an illegitimate name for *E. fistulosa* (Poir.) Schult., which is currently treated as a synonym of *E. acutangula* (Roxb.) Schult. However, this specimen differs from *E. acutangula* in having terete rather than triquetrous culms, longer floral scales, larger achenes with more numerous longitudinal rows of epidermal cells, and belongs instead to *Eleocharis liesneri* S. González & Reznicek. Additional collections of *E. liesneri* from near Sao Paulo, Brazil, and from Departamento de Antioquia, Colombia, were also discovered annotated as *E. mutata* (L.) Roem. & Schult and *E. acutangula* respectively. This species has not been recorded from Brazil or Colombia, being

previously known only from the type location in the highlands of SE Venezuela (González-Elizondo & Reznicek 1996). The discovery of a specimen of *E. liesneri* from Sao Paulo, ca. 3500 km SE of the type location, suggests that this poorly known taxon might be found in suitable habitat throughout the Brazilian Highlands (Fig. 1). The collection from Colombia suggests that *E. liesneri* has a peri-Amazonian distribution (personal communication, Socorro González-Elizondo). However, additional collections and a better understanding of the natural history (particularly habitat requirements) of this wetland species are needed to confirm this distribution. The purpose of this paper is to report these disjunct collections, and provide a key and illustration that might assist others in discovering additional misidentified specimens of *E. liesneri*.

As suggested by González-Elizondo and Reznicek (1996) *Eleocharis liesneri* is very near, and could be confused with *E. obtusetrigona* (Lindl. & Nees) Steud. (Fig. 2 d–f), an infrequently collected species belonging to subg. *Limnochloa*. Prior to the work of González-Elizondo et al. (2002), *E. obtusetrigona* had been poorly defined, being reduced to synonymy under *E. fistulosa* by Svenson (1939); or treated as a variety of *E. mutata*. (Clarke 1898) or *E. fistulosa* (Barros 1960). Both *E. liesneri* and *E. obtusetrigona* differ markedly from *E. mutata* in having usually terete rather than trigonous culms, larger achenes, a neck like constriction between the achene apex and tubercle, and larger floral scales.

A key to separate *Eleocharis liesneri* from *E. acutangula*, *E. mutata*, and *E. obtusetrigona*, along with a description modified from González-Elizondo and Reznicek (1996) and illustration are provided below. Achene lengths in the key include the tubercle.

KEY TO AID IN IDENTIFICATION OF *ELEOCHARIS LIESNERI* IN SOUTH AMERICA

1. Floral scales coarsely many veined (raised veins clearly discernable at 20×); achene apex markedly constricted to a short neck, the neck sometimes obscured by the style base.
   2. Culms terete or obscurely 3–5-angled distally or rarely trigonous with the culm faces flat or slightly convex and the angles obtuse in some specimens of *E. obtusetrigona*
      3. Achenes 2.8–3.2 mm long, 1.3–1.9 mm wide with 23–26 longitudinal rows of transversely oblong cells; exposed portion of floral scales longer than wide _____ **E. liesneri** (Fig. 2 a–c)
      3. Achenes (2.2)2.4 2.9(–3.1) mm long, 1.3–1.5(–1.6) mm wide with 11–18 longitudinal rows of transversely reniform cells; exposed portions of floral scales about as long as wide _____ **E. obtusetrigona** (Fig. 2 d–f)
   2. Culms triquetrous distally, the culm faces concave and the angles acute-winged _____ **E. acutangula**
1. Floral scales finely many veined (raised veins not clearly discernable at 20×); achene apex slightly constricted at the summit into a nard annular thickening of the same texture and color as the achene _____ **E. mutata**

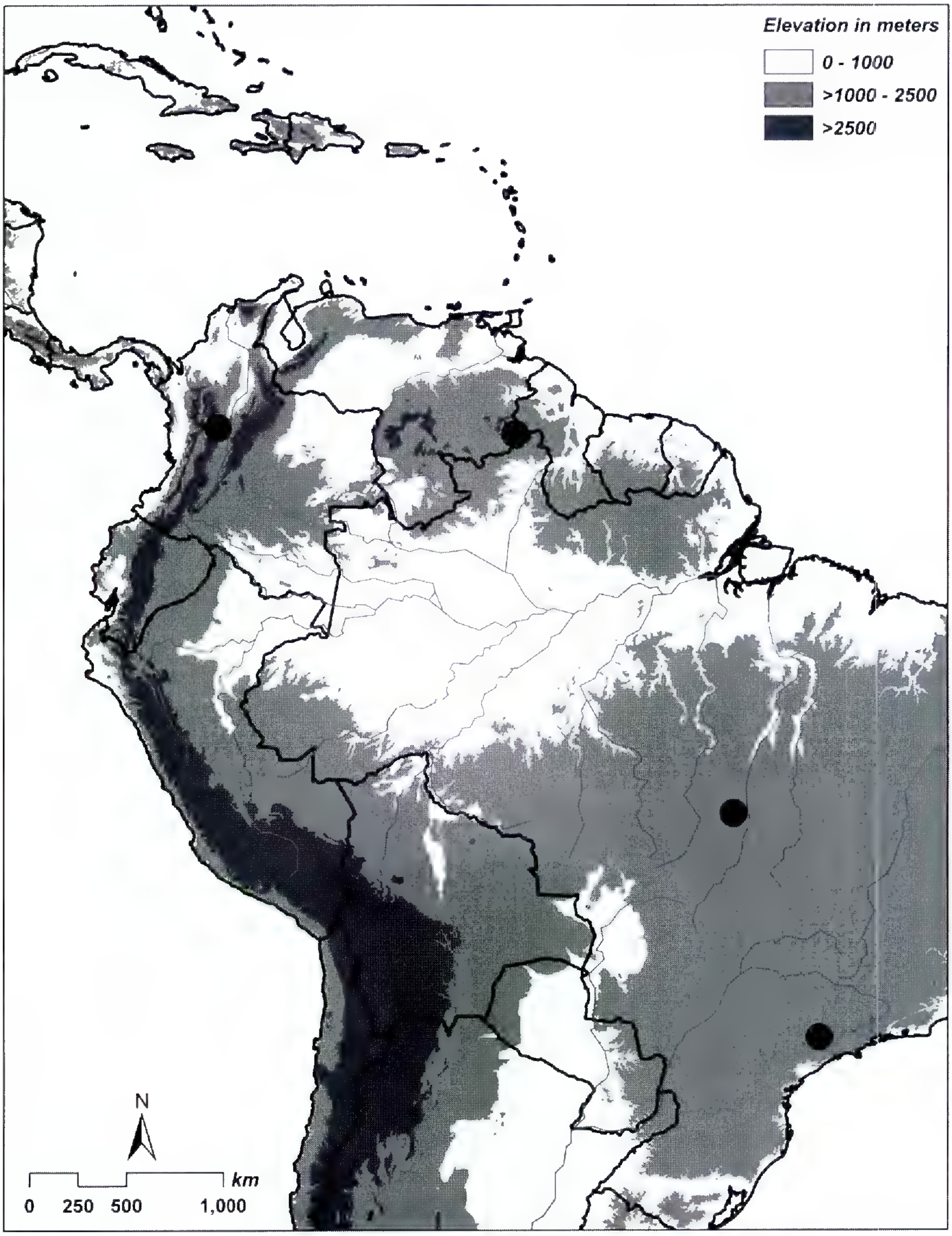


FIG. 1. Peri-Amazonian distribution of *Eleocharis liesneri* S. González & Reznicek.

Eleocharis liesneri S. González & Reznicek, Novon 6:361. 1996. (**Fig. 2a–c**). TYPE: VENEZUELA. BOLÍVAR: Gran Sabana, ca. 10 km SW of Karaurin Tepui at junction of Río Karaurin and Río Asadon (Río Sanpa), gallery forest, 5°19'N, 61° 03'W, 900–1000 m, riverbank, 23 Apr 1988, *R. Liesner 23698* (HOLOTYPE: MO!; ISOTYPE: NY!).

Perennial herb; roots coarse, fibrous, dark drab brown; rhizomes elongated, to

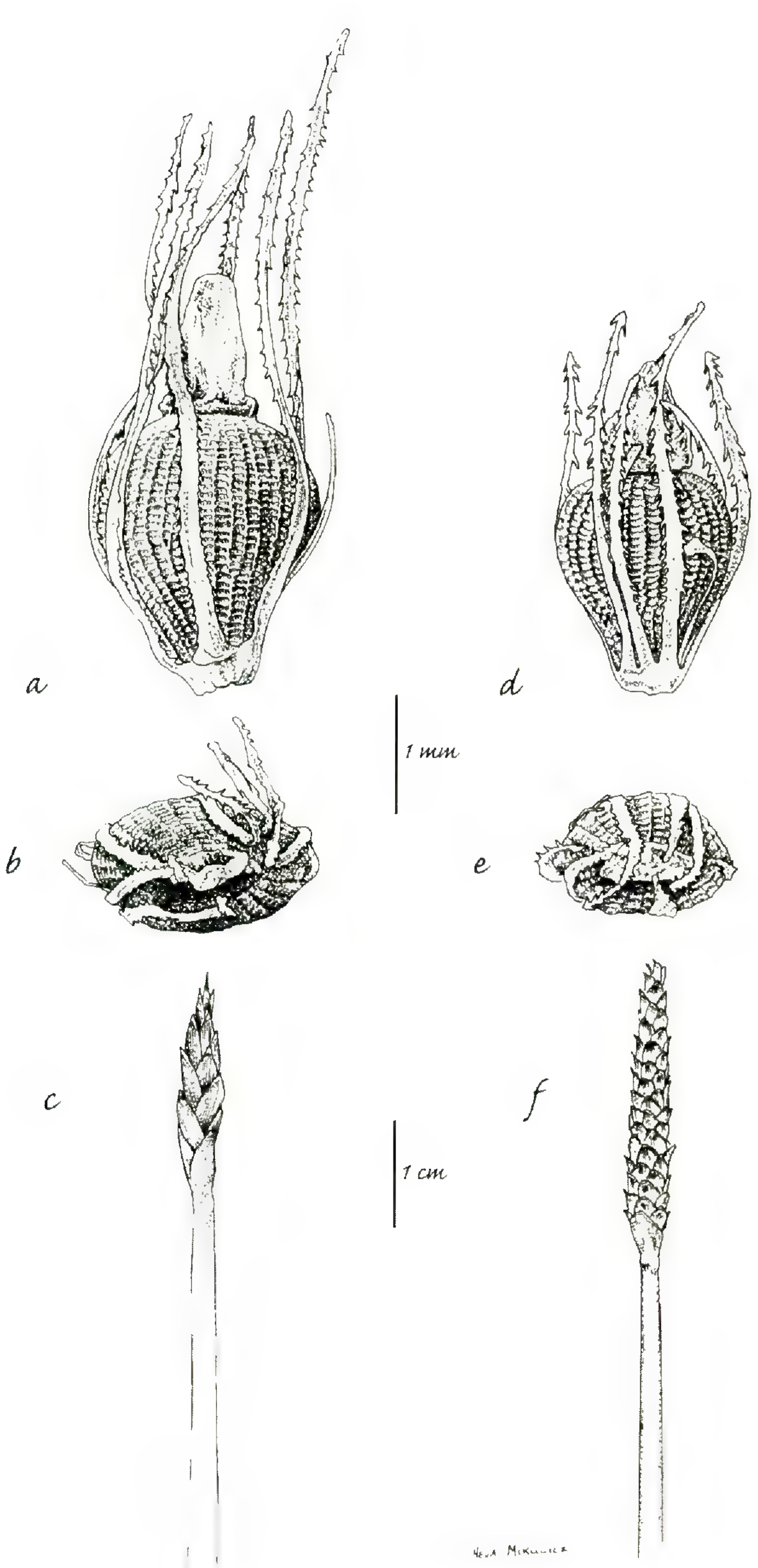


FIG. 2. *Eleocharis liesneri* S. González & Reznicek. **a–b.** Detail of achene, perianth bristles, and tubercle. **c.** Detail of spikelet and distal end of culm. *Eleocharis obtusetrigona* (Lindl. & Nees) Steud. **d–e.** Detail of achene, perianth bristles, and tubercle. **f.** Detail of spikelet and distal end of culm. a–c drawn from *Liesneri 23698* (MO) and d–f drawn from *Pedersen 7634* (C) by Neva Mikulicz.

ca. 1.8 mm thick, scales not seen, tubers absent; culms (when dry) terete or distally obscurely 3-angled, 40–65 cm × 2–4.4 mm, rigid, internally spongy, with incomplete transverse septa, finely longitudinally striate, olive-brown; leaves reduced to sheaths, sheaths 2, apically notched, membranous, loose, friable, variable in color proximally from dark brown to maroon, distally cinnamon to rufous, apex acute; spikelet cylindric, narrowly-lanceolate, 1.6–2.4 cm × 3.9–4.5 mm, acute, proximal scale empty, obtuse, amplexicaul, appearing as a continuation of the culm; floral scales appressed to weakly spreading, oblong, 5.5–6.2 mm × 2.3–3.2 mm, distal and medial 0.2-0.5 mm hyaline-erose, cartilaginous, darkish centrally or subapical dark splotch, reddish-stramineous marginally, apex acute (the distally hyaline region obtuse-rounded if present), central area nearly flat, coarsely many veined, mid-vein not distinguishable abaxially, conspicuous in adaxial view; perianth bristles 6–8, sub-equal, exceeding the tubercle, ascending, broad and strap-shaped proximally, coarsely retrorsely spinulose nearly to the base, the spinules coarse distally, becoming finer and more closely spaced proximally, stramineous; stamens 3; style trifid; achene biconvex, more or less obovoid to broadly obpyriform, 2.8–3.2 mm (including tubercle) × 1.3 –1.9 mm, with 23–26 longitudinal rows of deeply concave transversely oblong polygonal cells visible through transparent periclinal layer on each achene face, dull, buff, maturing to shiny light brown, apex constricted to about 0.4 times the width of the achene to a distinct neck (this sometimes obscured by the style base); tubercle dorsoventrally compressed, triangular, 0.5–1.2 mm × 0.7–0.9(–1) mm, dark brown.

Specimen citations. **BRAZIL. Mato Grosso do Sul:** Central Brazilian Plateau, ca. 1-3 km W of Km 261 Xavantina-Cachimbo road, in standing water in wet forest marsh, 12° 49'S, 51° 46'W, 19 Jan 1968, *Philcox & Fereira 4124* (NY). **Sau Paulo:** Gesammelt in Sud-Brasilien um Sao Paulo, without date (specimen bears annotation by C. B. Clarke dated 24 Apr 1906), *Usteri s.n.* (ZT). **COLOMBIA. Departamento de Antioquia:** Mpio. de Sonson, km 4 of road Sonson-La Union (52 km from La Union), disturbed roadside vegetation, 05° 44' N, 75° 18' W, 2480 m, 04 Oct 1987, *Zarucchi et al. 6240* (MO).

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NEW AND SIGNIFICANT RECORDS OF VASCULAR PLANTS FOR FLORIDA AND FOR COLLIER COUNTY AND LEE COUNTY, FLORIDA

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ABSTRACT

Documented records are reported for 89 taxa (81 species, 7 varieties, and one hybrid) from Collier County (31 taxa) and from Lee County (71 taxa), Florida (102 records altogether). A newly discovered hybrid, *Carex gigantea* × *Carex lupuliformis*, is discussed.

KEY WORDS: Florida, native species, alien species, new records, hybrid

RESUMEN

Se realizan las citas documentadas de 89 taxa (81 especies, 7 variedades, y un híbrido) de Collier County (31 taxa) y de Lee County (71 taxa), Florida (102 citas en total). Se discute un híbrido descubierto nuevamente, *Carex gigantea* × *Carex lupuliformis*.

INTRODUCTION

Herein we present new documented records of taxa of vascular plants from Collier County and/or Lee County, Florida, and we also discuss a *Carex* hybrid here reported for the first time in the literature.

Collier County and Lee County occur within the southwestern portion of the Florida Peninsula and border one another from south to north, respectively. These counties encompass 2,026 and 804 square miles, respectively (Southwest Florida Regional Planning Council 2002). They merit especial attention for five reasons.

(1) Gann et al. (2002), who grouped Collier and Lee counties among South Florida's counties, characterized South Florida as "... one of the most biologically diverse regions in North America." They reported over 2,200 species of native and naturalized plants from South Florida, including over 1,400 native species. By contrast, Wunderlin and Hansen (2003) recognized less than twice as many native and nonnative taxa (species, infraspecific taxa, and hybrids) for Florida's 67 counties, overall (i.e., 4,145 taxa). Wunderlin and Hansen (2004) listed the following numbers of taxa for the ten South Florida counties recognized by Gann et al. (2002): Broward Co., 1001; Charlotte Co., 709; Collier Co., 1194; Glades Co., 485; Hendry Co., 493; Lee Co., 1172; Martin Co., 988; Miami-

Dade Co., 1655; Monroe Co., 575, 776 (the mainland portion of Monroe Co. and the Florida Keys, respectively); and Palm Beach Co., 1036.

(2) South Florida extends into the subtropics, thus exhibiting impressive overlap between typically temperate, and characteristically tropical vegetation. Coordinate with their subtropical milieu, at all times of year Collier and Lee counties exhibit particular species in flower.

(3) Both counties manifest intense residential and commercial development. Within extensive areas their floras are being decimated, and increasing numbers of taxa face extirpation or rarity. The Southwest Florida Regional Planning Council (2002) defined Southwest Florida as consisting of six counties, including Collier and Lee counties. From 1950 to 2000, Southwest Florida's share of total U.S. population increased over nine-fold, from 0.047% to 0.429%. Similarly, from 1950 to 2000 Southwest Florida's share of Florida's population increased nearly three-fold, from 2.571% to 7.550%; the latter increase transpired despite the circumstance that Florida's population growth exceeded that of the U. S., overall.

(4) Together with Hawaii, Florida ranks among the two states "...with the most severe nonnative species problems..." (Simberloff 1997). One-third of the South Florida flora consists of escaped, nonnative plants (Gann et al. 2002). Simberloff (1997) stated that two primary factors predispose Florida, particularly southern Florida, to invasion by, and damage from nonnative species: (*a*) "...destruction and disturbance of native habitats and their replacement by novel habitats..." and (*b*) " ...the geographic features of tropicality, insularity, and the great expanse of aquatic habitats." Simberloff (1997) considered the problem of nonnatives to be aggravated by the considerable tourism and transportation into Florida.

(5) No flora has been published for Collier County or Lee County.

Climate

Annually, Collier and Lee counties exhibit a warm rainy season and cooler dry season. During the dry season shallow, rain-fed pools dry up and the land appears drier, overall.

Liudahl et al. (1998) cited data gathered at Fort Myers (Lee Co.)—20 miles north of Collier County—to characterize the climate of Collier County. Thus, those data represent both counties. They indicated annual average temperature of nearly 74° F, and temperatures ranging from an average within the low sixties in January to the low eighties during summer. Average daily maximum temperatures vary from 74.7° F (January) to 91.1° F (August); corresponding daily minimum temperatures for the two months are 53.6° F and 74.1° F.

Frost develops few times, yearly (Liudahl et al. 1998). Collier and Lee counties each exhibit USDA plant hardiness zone nos. 10a and 10b, and Lee County also exhibits zone 9b (these zones represent average annual minimum temperatures of 30°–35° F, 35°–40° F, and 25°–30° F, respectively; Anonymous 2005).

Average annual rainfall exceeds 50 inches. Approximately, two-thirds of rain falls from June to September, when average rainfall is nearly eight inches per month. Monthly average rainfall is less than two inches from November through January and is a little over two inches from February through April (Liudahl et al. 1998).

Geology and soils

Abutting the Gulf of Mexico and belonging to the Atlantic Coastal Plain, both counties exhibit low, flat terrain. They are part of a larger, unnamed, primarily southern and peripheral region of Florida exhibiting maximum elevation of 70 feet above sea level (Schmidt 1997). Physiographic regions prominent within Collier and Lee counties are the Big Cypress Spur, Caloosahatchee Valley, Gulf Barrier Chain and Gulf Coastal Lagoons, Immokalee Rise, Reticulate Coastal Swamps, and the Southwestern Slope (Liudahl et al. 1998; Schmidt 1997). Within each county, outcrops and shallow subcrop rocks are either Pliocene or Pleistocene-Holocene in age (Randazzo & Jones 1997).

Henderson, (1984) and Liudahl et al. (1998) surveyed the soils of both counties. For Collier Co., Liudahl et al. (1998) grouped general soil map units under either of three main headings: (1) urban land and soils in urban areas, (2) soils on the flatwoods and hammocks and in sloughs, and (3) soils on prairies and in swamps and freshwater marshes. For Lee Co., Henderson (1984) grouped major units similarly, but under four main headings: (1) soils of the manmade areas, (2) soils of the flatwoods and sloughs, (3) soils of the swamps and sloughs, and (4) soils of the tidal areas and barrier islands.

Ecosystems and land-use history

Despite their minimal ranges of elevations, both counties, collectively, exhibit diverse ecosystems, e.g., pine flatwoods, scrub, diverse kinds of hammocks, swamps, freshwater marshes, saltwater marshes, mangrove forests, and ruderal sites (Myers & Ewel 1990; Taylor 1998; G. Wilder, pers. obs.).

In addition to development, land use in Collier and Lee counties has entailed these extensive human-induced modifications: construction of drainage canals and of ditches for mosquito control; elimination of, and various alterations of wetlands; cattle ranching; row-crop agriculture; and lumbering. Both counties also maintain major preserves or portions of preserves: Big Cypress National Preserve, Collier Seminole State Park, Corkscrew Regional Ecosystem Watershed, Corkscrew Swamp Sanctuary, Fakahatchee Strand State Preserve, and Everglades National Park. Furthermore, Everglades restoration, currently underway partly within Collier and Lee counties, ranks among the largest of efforts for ecosystem restoration, worldwide.

MATERIALS AND METHODS

We made most collections between and including 2002 and 2005, however, we collected *Limnobium spongia* in 1994 and *Leptochloa nealleyi*, *Paspalum*

distichum, and *Scirpus pungens* in 1998; Appendix). All collections but one were prepared as dried herbarium specimens; *Landoltia punctata* was fixed in aqueous formalin-propionic acid-ethanol solution and stored in aqueous glycerin-ethanol solution. Specimens cited are deposited in the Herbarium of Southwestern Florida (SWF), housed at Florida Gulf Coast University (Fort Myers, FL). We characterize taxa as native, alien, and endemic, according to Wunderlin and Hansen (2003, 2004). Nomenclature for species and infraspecific taxa follows Wunderlin and Hansen (2003), but for several taxa we also provide commonly used synonyms. Family circumscriptions and common names also follow Wunderlin and Hansen (2003), except for Lemnaceae, Nyssaceae, and Asclepiadaceae, which we keep separate from Araceae, Cornaceae, and Apocynaceae, respectively.

The *Atlas of Florida Vascular Plants* (Wunderlin & Hansen 2004) was our principal source for determining whether taxa represented new county or state records. That database does not reference voucher specimens, however, Wunderlin (2002) specified that "Each distribution record on the atlas website is documented by an herbarium specimen or a reliable published source, such as a monograph or revision." We also recognized documented plant records from Austin et al. (1990) and Gann et al. (2002).

There exists a plethora of additional reports and inventories pertaining to the floras of Collier County and Lee County, which do not reference voucher specimens, which are unpublished, and/or which have insufficient circulation. Because of these shortcomings, we do not consider records cited within them as adequately established. As Wunderlin (2002) stated in regard to voucher specimens, if a "...species is not documented...there is no record that the plant ever existed..."

RESULTS AND DISCUSSION

Reported herein are 89 taxa (81 species, 7 varieties, and one hybrid) that represent 31 new documented records for Collier Co. and 71 for Lee Co., Florida (102 records altogether). The hybrid, *Carex gigantea* × *Carex lupuliformis*, is newly discovered and thus a new Florida record.

Asclepias feayi is included here, although it was documented previously. That species was originally collected near Immokalee (Collier Co.) in 1967 (Gann et al. 2002). It is cited here, because those workers designated *A. feayi* as historical in South Florida (including Collier Co.), a designation implying that the species might have been extirpated there.

Muss et al. (2003) published a plant-species list for the Big Cypress National Preserve, which includes portions of Collier, Miami-Dade, and Monroe counties. They listed nine species cited in this article: *Cyperus involucratus*, *Dalbergia sissoo*, *Eleocharis flavescens*, *Ixora coccinea*, *Limnophila sessiliflora*,

Melilotus albus, *Paspalum distichum*, *Reimarochloa oligostachya*, and *Senna alata*, but did not indicate which, if any, records represented Collier County.

The Institute for Regional Conservation (IRC) cites plant records for South Florida, from many sources (Gann et al. 2005). These records as presented by Gann et al. (2005) are undocumented and, therefore, not accepted here. Gann et al. (2005) cited four taxa that we report for Collier Co. (*Eleocharis flavescens*, *Limnophila sessiliflora*, *Melilotus albus*, *Scirpus californicus*) and eight taxa presently listed for Lee Co. (*Asclepias feayi*, *Cirsium nuttallii*, *Commelina gambiae*, *Palafoxia integrifolia*, *Paspalidium geminatum*, *Paspalum conjugatum*, *Phyllanthus amarus*, *Quercus chapmanii*).

Taxonomic data

The 89 taxa represent pteridophytes (1 taxon; 1.1 % of taxa), monocotyledons (44 taxa; 49.4%), and dicotyledons (44 taxa; 49.4%). Numbers of families in each group are: 1 (pteridophytes), 10 (monocotyledons), and 24 (dicotyledons; Appendix).

Families of monocotyledons with the most taxa are Poaceae (21 taxa) and Cyperaceae (15 taxa). Remaining monocotyledonous families each include one taxon. The 36 taxa of Poaceae and Cyperaceae, collectively, constitute 40.4 % of presently reported taxa. This disproportionately high percentage suggests that previous collectors within Collier and Lee counties documented these families insufficiently. Families of dicotyledons with the most taxa are Fabaceae (8), Asteraceae (5), Veronicaceae (5), Euphorbiaceae (4), Brassicaceae (2), and Urticaceae (2). Remaining dicotyledonous families each include one taxon.

Native and Endemic Taxa

Wunderlin and Hansen (2003) classified as native to Florida 48 (53.9%) of the 89 taxa reported here (Appendix). They listed two of our taxa as endemic to Florida (*Asclepias feayi* and *Linum carteri*; Appendix). We consider *Carex gigantea* × *Carex lupuliformis* endemic, as well. In the Poaceae and Cyperaceae, the families most prominently represented in this study, 12 and 10 taxa are native, respectively (i.e., 57.1% and 66.7% of taxa of these families). The present report of a large proportion (ca. one-half) of nonnative taxa accords fairly well with the considerable proportion (ca. one-third) of such taxa indicated previously for South Florida (Gann et al. 2002) and for Florida, overall (Wunderlin & Hansen 2003).

Rare Florida Taxa

The eighty-nine records include a considerable number of rare taxa. Foremost, is *Carex gigantea* × *Carex lupuliformis*, first collected by George Wilder on April 22, 2003. We found that hybrid solely at one station, in Six Mile Cypress Slough Preserve (Lee County). Two years ago, Dr. Anton Reznicek (MICH) annotated three herbarium specimens of this hybrid as "a beautiful intermediate collection" (*Wilder & McCombs* [*W & M*] *17258*, *W & M 17259*, and *W & M 17260*).

Preliminary study revealed three differences between both parental species and the hybrid. (*1*) Perigynia exhibit achenes (both parental species), but are sterile (the hybrid); indeed, sterility is a common feature of hybrids, overall. (2) Relative to spike axes, perigynia extend at, or approximately at right angles (*C. gigantea*), are ascending (*C. lupuliformis*), and have generally intermediate orientations (the hybrid). (3) Spike diameters (excluding perigynium beaks) are narrow (*C. gigantea*), broad (*C. lupuliformis*), and intermediate (the hybrid).

Cayouette and Catling (1992), in their comprehensive review of *Carex* hybrids, referred to "*Carex gigantea* Rudge × *lupulina* Willd. (? *lupuliformis* Sartwell). Possible hybrid origin according to Correll and Johnston (1970)." That language is interpretable in various ways—e.g., to mean the existence of *C. gigantea* × *C. lupuliformis*, however, the latter interpretation is incorrect. Correll and Johnston (1970) (who construed *C. lupuliformis* as a form of *Carex lupulina* Muhl., rather than as a discrete species) actually said of *C. lupuliformis*, that "...these plants seem to show the introgressive influence of *C. lupulina* by *C. gigantea*." Thus, Correll and Johnston (1970) suggested hybrid character of *C. lupuliformis*, overall, not a definite *C. gigantea*/*C. lupuliformis* hybrid.

Carex gigantea × *Carex lupuliformis* was not reported or recorded in *Flora of North America* (Reznicek 2002), in section Lupulinae of the genus *Carex*, nor was it indicated in floristic manuals listing both parental species (Fernald 1950; Gleason 1968; Gleason & Cronquist 1991; Godfrey & Wooten 1979; Mohlenbrock 1999; Small 1933; Wunderlin & Hansen 2003). Some of these workers submerged, or apparently submerged *Carex lupuliformis* into *Carex lupulina* Muhl.

Leptochloa nealleyi and *Kyllinga hyalina* are also unusual in Florida. George Wilder collected *L. nealleyi* on Sanibel Island (Lee Co.), on Aug. 27, 1998 (*W & M 9774*). We know of one other Florida collection of *L. nealleyi*, from Miami-Dade County (*Keith A. Bradley 2583*, Aug. 19, 2004). *Leptochloa nealleyi* was listed by Wunderlin and Hansen (2004), but not by Wunderlin and Hansen (2003).

We collected *Kyllinga hyalina* in Collier County and Lee County, where it is a lawn weed and grows in disturbed areas. Two years ago, Dr. Anton Reznicek (MICH) annotated six of our specimens as "*Cyperus hyalinus* Vahl 2nd U.S. collection" (*W & M 17261* to *W & M 17266*, all of Sept. 8, 2002). (Wunderlin & Hansen [2002] listed *Cyperus hyalinus* Vahl and *Kyllinga hyalina* (Vahl) T. Koyama as synonyms).

Wunderlin and Hansen (2003) ranked 17 presently reported taxa as rare in Florida. We increase that number by two, by including *Carex giantea* × *Carex lupuliformis* and *Leptochloa nealleyi* (taxa which those workers did not consider). Based on data from Wunderlin and Hansen (2003) and on our assessments of these two taxa, the 89 taxa considered here are ranked for Florida, as follows: rare, 19 taxa (21.3% of all 89 taxa); occasional, 48 taxa (53.9%); common, 4 taxa (4.5%); and frequent, 19 taxa (21.3%). Rare and occasional taxa predominate among our

collections—composing, collectively, three-quarters of taxa presently listed. Common and frequent taxa represent, collectively, ca. one quarter of taxa.

Wunderlin and Hansen (2003) listed as rare in Florida the following of our taxa: *Acalypha arvensis*, *Acalypha setosa*, *Achyranthes aspera* var. *pubescens*, *Alysicarpus vaginalis*, *Callitriche pedunculosa*, *Chamaesyce lasiocarpa*, *Commelina gambiae*, *Dalbergia sissoo*, *Heteropogon contortus*, *Ixora coccinea*, *Kyllinga hyalina*, *Leptochloa virgata*, *Linum carteri*, *Paspalum nicorae*, *Senna alata*, *Spigelia anthelmia*, and *Zoysia tenuifolia*. Five of the nineteen taxa designated as rare by Wunderlin and Hansen (2003) and by ourselves, collectively, are native to Florida (Appendix).

For Florida, Coile and Garland (2003) classified *Linum carteri* as endangered and *Tillandsia variabilis* [*Tillandsia valenzuelana* A. Rich.] as threatened.

Gann et al. (2002) considered as rare in South Florida eight species presently listed. They indicated two of these species as extirpated (*Lipocarpha maculata* ["collected once in 1965 near Immokalee"], *Scirpus californicus* ["last collected in 1965 near South Bay in Palm Beach County"]), two species as historical (*Asclepias feayi* ["last collected in 1967 near Immokalee"], *Reimarochloa oligostachya* ["last collected in 1977"]), and four species as critically imperiled (*Leptochloa virgata*, *Nyssa sylvatica*, *Rhynchospora baldwinii*, *Rhynchospora wrightiana*).

We documented Gann et al's (2002) eight taxa from various localities: *Lipocarpha maculata* (Lee Co., 2 localities), *Scirpus californicus* (Collier Co., 1 locality), *Asclepias feayi* (Collier Co., 1 locality; Lee Co., 6 localities), *Reimarochloa oligostachya* (Collier Co., 1 locality), *Leptochloa virgata* (Lee Co., 3 localities), *Nyssa sylvatica* (Lee Co., 1 locality), *Rhynchospora baldwinii* (Collier Co., 1 locality; Lee Co., 1 locality), and *Rhynchospora wrightiana* (Collier Co., 1 locality).

Directions and extents of Range Extensions

Data from Wunderlin and Hansen (2004) indicate that 24 of our taxa represent range extensions southward in Florida: *Acalypha setosa*, *Anthaenantia villosa*, *Callitriche pedunculosa*, *Chasmanthium nitidum*, *Cyperus lanceolatus*, *Dalea carnea* var. *albida*, *Dichanthelium strigosum* var. *leucoblepharis*, *Hemarthria altissima*, *Iris virginica*, *Lindernia dubia* var. *dubia*, *Poa annua*, *Monotropa uniflora*, *Nyssa sylvatica*, *Portulaca amilis*, *Rhynchospora baldwinii*, *Rhyncho-spora filifolia*, *Rhynchospora wrightiana*, *Rumex obovatus*, *Scirpus californicus*, *Solidago canadensis* var. *scabra*, *Sphenopholis obtusata*, *Stylosanthes biflora*, *Urochloa texana*, and *Urtica chamaedryoides*.

Fewer range extensions within Florida are northward (*Leptochloa virgata*), westward (*Ixora coccinea*, *Spigelia anthelmia*), both southward and eastward (*Sida santaramensis*), and both northward and westward (*Kyllinga hyalina*, *Leptochloa nealleyi*).

For each of our taxa except the *Carex* hybrid, we gauged the relative distance between the county (or two counties, collectively) newly represented here and the nearest county indicated by Wunderlin and Hansen (2004). For 60 taxa the newly reported county (or counties, collectively) bordered one or more of the indicated counties. For 21 taxa one or two counties intervened between the newly reported county (or counties, collectively) and the nearest county. For five taxa the number of intervening counties was 3 or 4 (*Iris virginica*, *Callitriche pedunculosa*, *Dalea carnea* var. *albida*, *Stylosanthes biflora*, *Sida santaremensis*). For three taxa between 6 and 8 counties intervened (*Dichanthelium strigosum* var. *leucoblepharis*, *Solidago canadensis* var. *scabra*, *Lindernia dubia* var. *dubia*).

Prognosis for presently discussed taxa

Development and habitat destruction are explosive within Collier County and Lee County, and we anticipate accelerated destruction of taxa and habitat in these counties. Certain localities represented herein have already been destroyed, and the following taxa are now extirpated from one or more localities represented in this paper: *Asparagus aethiopicus*, *Cirsium nuttallii*, *Cyperus sphacelatus*, *Melilotus albus*, *Melilotus indicus*, *Paspalum conjugatum*, *Paspalum notatum* var. *notatum*, *Penstemon multiflorus*, *Polygala verticillata*, and *Urochloa texana*.

APPENDIX

The following list of species, varieties, and a hybrid represent new documented records for Collier County and Lee County, Florida.

Data are presented in the following order after the Latin name of a species, hybrid, or variety: relevant synonym, if any (between brackets); common name; the Wilder and McCombs collection number(s) of voucher specimen(s); habitat(s) where the species was collected; Wunderlin and Hansen's (2003) assessment of frequency of the taxon in Florida; and county(ies) for which the taxon is presently documented. For individual taxa documented for both Collier Co. and Lee Co., collection numbers are indicated in the order listed of these counties. * = alien to Florida; Σ = endemic to Florida.

PTERIDOPHYTE

THELYPTERIDACEAE

**Macrothelypteris torresiana* (Gaudich.) Ching, Mariana Maiden Fern—22,158; damp forest; occasional; Lee

MONOCOTYLEDONS

ALISMATACEAE

Sagittaria latifolia Willd., Broad eaf Arrowhead – 22697; damp soil; occasional; Lee

ASPARAGACEAE

**Asparagus aethiopicus* L. [*Asparagus sprengeri* Regel], Sprenger's Asparagus-Fern—20731; scrub; occasional; Collier

BROMELIACEAE

Tillandsia variabilis Schltdl., Leatherleaf Airplant—22194; swamp; occasional; Lee

COMMELINACEAE

**Commelina gambiae* C.B. Clarke, Gambian Dayflower—22522; highly insolated, disturbed land; edge of field; rare; Lee

CYPERACEAE

Σ *Carex gigantea* Rudge × *Carex lupuliformis* Sartwell ex Dewey—19688; swamp; rare; Lee

**Cyperus involucratus* Rottb. [*Cyperus alternifolius* L.], Umbrella Plant—18666; insolated land beneath power lines; occasional; Collier

**Cyperus lanceolatus* Poir., Epiphytic Flatsedge—19847; wetland within insolated, cleared land; insolated land bordering trail; occasional; Lee

**Cyperus sphacelatus* Rottb., Roadside Flatsedge—19715, 18686; bulldozed, insolated land; insolated lawn; occasional; Collier, Lee

Eleocharis flavescens (Poir.) Urb., Yellow Spikerush—20749; along/on shaded trail through damp lowland; frequent; Collier

**Kyllinga hyalina* (Vahl) T. Koyama [*Cyperus hyalinus* Vahl], Peduncled Spikesedge—disturbed land; lawn; 18498, 17265; rare; Collier, Lee

Kyllinga pumila Michx., Low Spikesedge—22033; disturbed land; occasional; Lee

**Kyllinga squamulata* Thonn. Ex Vahl, Asian Spikesedge—18645; pine flatwoods; occasional; Lee

Lipocarpha maculata (Michx.) Torr., American Halfchaff Sedge—18030; insolated wetland beneath power lines; disturbed land (formerly either pine flatwoods or scrub); on trail; occasional; Lee

Rhynchospora baldwinii A. Gray, Baldwin's Beaksedge—19780; wet portion of pine flatwoods; occasional; Collier

Rhynchospora filifolia A. Gray, Threadleaf Beaksedge—19084; periphery of pond; other wetland; frequent; Collier

Rhynchospora grayi Kunth, Gray's Beaksedge—17911; pine flatwoods; occasional; Lee

Rhynchospora wrightiana Boeck., Wright's Beaksedge—19812; along firebreak through pine flatwoods; occasional; Collier

Scirpus californicus (C.A. Mey.) Steud., Giant Bulrush—16332; edge of pond; occasional; Collier

Scirpus pungens Vahl, Threesquare Bulrush—9790, 19209; insolated wet and; roadside; frequent; Collier, Lee

HYDROCHARITACEAE

Limnobium spongia (Bosc) Rich. ex Steud., American Spongeplant—7392; occasional; in canal; Lee

HYPOXIDACEAE

Hypoxis curtissii Rose, Common Yellow Star-grass -20142; swamp; common; Lee

IRIDACEAE

Iris virginica L., Virginia Iris—18207; insolated depression along road; occasional; Lee

LEMNACEAE

**Landoltia punctata* (G. Mey.) Les & D. J. Crawford, Dotted Duckweed—shallow water; frequent; Lee

POACEAE

Anthaenantia villosa (Michx.) P. Beauv., Green Silkyscale—19282; pine flatwoods; frequent; Lee

**Bothriochloa ischaemum* (L.) Keng, King Ranch Bluestem—19118; pasture; occasional; Lee

Cenchrus gracillimus Nash, Slender Sandbur—19178, 21335; along dirt road through bulldozed land; strand vegetation by Gulf of Mexico; frequent; Collier, Lee

Chasmanthium nitidum (Baldwin) Yates, Shiny Woodoats—22291; Hammock; occasional; Lee

Dichanthelium strigosum var. *leucoblepharis* (Trin.) Freckmann—19364; edge of trail through open woodland; occasional; Lee

**Hemarthria altissima* (Poir.) Stapf & C. E. Hubb., Limpograss—20728; edge of pond; occasional; Collier

Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult., Tanglehead—19467; pine flatwoods; along railroad tracks; rare; Lee

**Leptochloa nealleyi* Vasey, Nealley's Sprangletop—9774; disturbed land on Sanibel Island; rare; Lee

Leptochloa virgata (L.) P. Beauv., Tropical Sprangletop—22364; damp depression along road; rare; Lee

Panicum anceps Michx., Beaked Panicum—22126; wet prairie; pine flatwoods; on trail; common; Lee

Paspalidium geminatum (Forssk.) Stapf, Egyptian Paspalidium—22686; insolated wetland; occasional; Lee

Paspalum conjugatum P.J. Bergius, Sour Paspalum—21578; hammock; recently bulldozed, highly insolated land; along dirt road; occasional; Lee

Paspalum distichum L., Knotgrass—9787; disturbed land; occasional; Collier

**Paspalum nicorae* Parodi, Brunswickgrass—21583; pine flatwoods; rare; Lee

**Paspalum notatum* Flugge var. *notatum*, Bahiagrass—21370; bulldozed, highly insolated land; occasional; Lee

**Poa annua* L., Annual Bluegrass—19550, 19554; lawn; shaded, bare earth bordering sidewalk; frequent; Collier, Lee

Reimarochloa oligostachya (Munro ex Benth.) Hitchc., Florida Reimargrass—21136; meadow; occasional; Collier

**Secale cereale* L., Cultivated Rye—22847; bulldozed, highly insolated land; occasional; Lee

Sphenopholis obtusata (Michx.) Scribn., Prairie Wedgescale—19594; field; frequent; Lee

**Urochloa texana* (Buckley) R. D. Webster, Texas Signalgrass - 19633; bulldozed, highly insolated land; occasional; Lee

**Zoysia tenuifolia* Willd. ex Thiele, Manila Templegrass—19638, 22397; disturbed land; rare; Collier, Lee

DICOTYLEDONS

ACANTHACEAE

**Thunbergia fragrans* Roxb., Whitelady—22253; disturbed hammock, edge of field; occasional; Lee

AIZOACEAE

Sesuvium maritimum (Walter) Britton et al., Slender Seapurslane—21161; insolated trail; occasional; Coll.

AMARANTHACEAE

**Achyranthes aspera* var. *pubescens* (Moq.) C. C. Towns., Devil's Horsewhip—21102; oak Sabal hammock within Caloosahatchee River Regional Park; rare; Lee

ASCLEPIADACEAE

Σ *Asclepias feayi* Chapm. ex A. Gray, Florida Milkweed—17874; scrub, on/along trails through pine flatwoods, grassy portion of pineland remnant, disturbed land (formerly, apparently pine flatwoods); occasional; Lee

ASTERACEAE

Cirsium nuttallii DC., Nuttall's Thistle—16631; lawns (including tree lawn); frequent; Lee

**Cyanthillium cinereum* (L.) H. Rob. [*Vernonia cinerea* (L.) Less.]—18454; along/on dirt road; occasional; Collier

Palafoxia integrifolia (Nutt.) Torr. & A. Gray, Coastalplain Palafox—22101; field; pineland; frequent; Lee

Solidago canadensis L. var. *scabra* (Muhl. ex Willd.) Torr. & A. Gray—18432, 17315; median strip of I 75; along road; wet prairie; shallow water; frequent; Collier, Lee

**Taraxacum officinale* Weber ex F. H. Wigg. [including *Taraxacum laevigatum* (Willd.) DC]—19682, 18787 (red-fruited and brown-fruited formas, respectively); occasional; Lee

BRASSICACEAE

**Coronopus didymus* (L.) Sm., Lesser Swinecress.—20394, 20397; highly insolated dirt pile; lawn weed; occasional; Collier, Lee

Descurainia pinnata (Walter) Britton, Western Tansymustard 20401; tree lawns along main roads; common; Lee

CALLITRICHACEAE

**Callitriche pedunculosa* Nutt., Nuttall's Waterstarwort—22289; damp soil in shallow depression situated within cleared land beneath power lines; rare; Lee

ERICACEAE

Monotropa uniflora L., Indianpipe—16699; shaded portion of scrub; occasional; Collier

EUPHORBIACEAE

**Acalypha arvensis* Poepp., Threeseed Mercury - 17225; disturbed land by creek; rare; Lee

**Acalypha setosa* A. Rich., Cuban Copperleaf—18821; shrub bed within supermarket parking lot; rare; Lee

**Chamaesyce lasiocarpa* (Klotzsch) Arthur, Roadside Sandmat—19225; field; tree lawn; insolated wasteland; crack in pavement; rare; Lee

**Phyllanthus amarus* Schumach. & Thonn., Gale-Of-Wind—21947; insolated, recently bulldozed land of median of road; occasional; Lee

FABACEAE

**Alysicarpus vaginalis* (L.) DC., White Moneywort—18939; insolated, dry substrate of median of road; land by intersection; rare; Lee

**Dalbergia sissoo* Roxb. ex DC., Indian Rosewood—21427; along railroad tracks; rare; Collier

Dalea carnea var. *albida* (Torr. & A. Gray) Barneby, Whitetassels—17934; pine flatwoods; occasional; Lee

**Melilotus albus* Medik., White Sweetclover—16471; field; frequent; Collier

**Melilotus indicus* (L.) All., Indian Sweetclover—19022, 16905; bulldozed land; insolated dirt pile; occasional; Collier, Lee

Mimosa quadrivalvis L., Sensitive Brier—17883; field; frequent; Lee

**Senna alata* (L.) roxb., Candlestick Plant—19040, 16469; disturbed land; by power lines; construction site; rare; Collier, Lee

Stylosanthes biflora (L.) Britton et al.– 22524; bordering, and extending into ditch; occasional; Lee

FAGACEAE

Quercus chapmanii Sarg., Chapman's Oak.—17198; scrub; pineland; edge of disturbed forest; frequent; Lee

ITEACEAE

Itea virginica L., Virginia Willow—20580; forest by creek; common; Lee

LINACEAE

Σ *Linum carteri* Small, Carter's Flax—16958; field; rare; Lee

MALVACEAE

**Sida santaremensis* Monteiro, Moth Fanpetals—20781; edge of field; occasional; Collier

MORACEAE

Morus rubra L., Red Mulberry—19757; hammock, disturbed land; frequent; Lee

NYSSACEAE

Nyssa sylvatica Marshall, Tupelo—20834; shore of pond; frequent; Lee

POLYGALACEAE

Polygala verticillata L., Whorled Milkwort—22279; edge of field; occasional; Lee

POLYGONACEAE

**Rumex obovatus* Danser, Tropical Dock—16909, insolated land by canal; dried-up ditch; weedy sod; occasional; Lee

PORTULACACEAE

**Portulaca amilis* Speg., Paraguayan Purslane—20769, 21705; edge of insolated, bulldozed land; lawn weed; frequent; Collier, Lee

RUBIACEAE

**Ixora coccinea* L., Scarlet Jungleflame —21085; natural land; rare; Collier, Lee

STRYCHNACEAE

Spigelia anthelmia L., West Indian Pinkroot—21232; insolated gravel and bulldozed land; tree lawn; meadow; rare; Collier; Lee

URTICACEAE

**Pouzolzia zeylanica* (L.) Benn., Pouzolz's Bush—21259; disturbed land along road; insolated dump; occasional; Lee

Urtica chamaedryoides Pursh, Heartleaf Nettle.—21263; lawn weed; occasional; Lee

VERBENACEAE

**Verbena brasiliensis* Vell., Brazilian Vervain—19764; depression by intersection; dried-up, barren portion of lawn; occasional; Lee

VERONICACEAE

**Limnophila sessiliflora* Blume, Asian Marshweed—21181; damp substrate along canal; occasional; Collier

Lindernia dubia var. *anagallidea* (Michx.) Cooperr., Yellowseed False Pimpernel.—21196; damp trench through insolated, bulldozed land (growing together with the following variety); occasional; Lee

Lindernia dubia (L.) Pennell var. *dubia*—21199; damp trench through insolated, bulldozed land; occasional; Lee

Penstemon multiflorus (Benth.) Chapm. ex Small, Manyflower Beardtongue—22283; scrub; field; frequent; Lee

**Russelia equisetiformis* Schltdl. & Cham., Fountainbush—19970; disturbed land; occasional; Collier

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Martha J. Groom, Gary K. Meffe, and C. Ronald Carroll. 2005. **Principles of Conservation Biology, Third Edition.** (ISBN 0-87893-518-5, hbk.). Sinauer Associates, Inc., 23 Plumtree Road, Sunderland, MA 01375-0407; U.S.A. (**Orders:** orders@sinauer.com, www.sinauer.com, 413-549-4300, 413-549-1118 fax). $92.95, 699 pp., 369 illustrations, 8 1/2" × 11".

From the publisher.—"*Principles of Conservation Biology, Third Edition,* features a wholly revised organization, emphasizing analyses of different categories of threat and approaches to conservation. Coverage has been expanded to incorporate both terrestrial and marine conservation issues, and efforts in the U.S. and across the globe.

Inderjit (Ed.). 2005. **Invasive Plants: Ecological and Agricultural Aspects.** (ISBN 3-7643-7137-4; 978-3-7643-7137-1, hbk.). Birkhauser Verlag, P.O. Box 133, CH-4010 Basel, SWITZERLAND. (**Orders:** www.springer.com). $159.00, 283 pp., illustrations, 6 1/2" × 9 1/4".

From the publisher.—The aim of this book is to discuss fundamental questions of invasion ecology, such as why particular communities become more invasible than others, what the mechanisms of exclusion of native species by invaders are, and whether invasion can be predicted.

In addition, agricultural practices influencing invasion, the environmental and economic costs of invasion as well as possible management strategies are discussed. Readers will get a unique perspective on invasion ecology through employing general principles of ecology to plant invasions.

CAREX BICKNELLII (CYPERACEAE) NEW TO ARKANSAS

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ABSTRACT

We report the first record of *Carex bicknellii* Britt. for Arkansas. The species was collected by the authors in 2003 and 2005 from Baker Prairie Natural Area, an unplowed tallgrass prairie remnant in Boone County, Arkansas.

RESUMEN

Se realiza la primera cita de *Carex bicknellii* Britt. para Arkansas. La especie se colectó por los autores en 2003 y 2005 en Baker Prairie Natural Area, una pradera de hierba alta remanente en Boone County, Arkansas.

The range of *Carex bicknellii* Britt. extends from Maine and Manitoba south to Kansas and South Carolina, with the bulk of the distribution extending from Missouri and southeastern Kansas northward to southeastern Manitoba and the western end of Lake Erie (Rothrock & Reznicek 2001; Mastrogiuseppe et al. 2002). Disjunct populations occur in Maine, western Kansas, South Carolina, and the eastern Lake Ontario Region (Rothrock & Reznicek 2001). Habitat for the species includes dry to mesic prairies, rock, sand or serpentine barrens, open woodlands, openings in mesic to dry upland forests and bluff ledges, dry sandy or rocky fields, thickets, and less commonly along margins of ponds and fens (Yatskievych 1999; Rothrock & Reznicek 2001; Mastrogiuseppe et al. 2002). Orzell and Bridges (1987) and Smith (1988) reported *C. bicknellii* (as *C. bicknellii* var. *bicknellii*) for Franklin County, Arkansas but the specimen (Barber 861, UARK), which was the basis for the reports, was subsequently annotated by A.A. Reznicek as *Carex bicknellii* Britt. var. *opaca* F.J. Herm. (J. Gentry, UARK, in litt. 21 October 2005). Hyatt (1988), Rothrock and Reznicek (2001), and Mastrogiuseppe et al. (2002) did not include Arkansas within the range of *Carex bicknellii* (either as *C. bicknellii* or as *C. bicknellii* var. *bicknellii*). Rothrock and

Reznicek (2001) referenced all specimens within the *C. bicknellii* group collected in Arkansas through 2000 and determined that all prior reports of *C. bicknellii* (as *C. bicknellii* var. *bicknellii*) in Arkansas were based on other species.

On 9 May 2005, the senior author discovered this species scattered in irregular colonies on dry mounds of Baker Prairie Natural Area, a 28 ha remnant of native tallgrass prairie in Boone County in north central Arkansas located near the western edge of the town of Harrison. On 10 May 2005, McKenzie and Witsell returned to the site to assess the overall distribution and abundance of the species on the area and to record plant associates. *Carex bicknellii* was associated with *Baptisia bracteata* Muhl. ex Elliott, *Berlandiera texana* DC., *Carex bushii* Mack., *Ceanothus americanus* L., *Commandra umbellata* (L.) Nutt., *Dodecatheon meadii* L., *Euphorbia corollata* L., *Hypoxis hirsuta* (L.) Cov., *Luzula bulbosa* (Alph. Wood) Rydb., *Physalis* sp., *Schizachyrium scoparium* (Michx.) Nash, *Silphium integrifolium* Michaux, *S. laciniatum* L., and *Tradescantia ohiensis* Raf. Plants were irregularly scattered over much of the drier portions of the prairie and extended to a few of the swales that drain the site. *Carex bicknellii* was initially collected on Baker Prairie in a wet swale by Witsell on 1 June 2003 but the specimen was incorrectly identified as the closely related *C. opaca* (F.J. Herm.) P.E. Rothrock & Reznicek.

With the exception of a small (approximately 4 ha) former pasture along its eastern edge, Baker Prairie Natural Area is a high quality unplowed prairie remnant, and is jointly owned by the Arkansas Natural Heritage Commission and the Arkansas Field Office of The Nature Conservancy. It is the only remnant of what was once an approximately 2000 ha tallgrass prairie located west and south of present day downtown Harrison and is the largest known remnant of Ozark prairie that occurs on a chert substrate in Arkansas (Arkansas Natural Heritage Commission 2004). Baker Prairie Natural Area occurs on the Boone Formation of the Springfield Plateau which is characterized by limestone with embedded chert (Harper et al. 1981, Arkansas Natural Heritage Commission 2004). The Natural Area is underlain by Nixa and Noark very cherty silt loams which are deep, well-drained, moderately permeable soils that formed in residuum from cherty limestone (Harper et al. 1981; Arkansas Natural Heritage Commission 2004). Elevation on the natural area ranges from 354 to 378 m above mean sea level on slopes of 3 to 20 % (Arkansas Natural Heritage Commission 2004). Much of the natural area is gently rolling with scattered "pimple" mounds (Arkansas Natural Heritage Commission 2004). Baker Prairie includes dry-mesic chert prairie, mesic chert prairie (restricted to swales that bisect the area), and non-native grassland (Arkansas Natural Heritage Commission 2004). Major threats to the prairie prior to state ownership and restoration included lack of prescribed fire, excessive haying, the introduction of tall fescue (*Festuca arundinacea* Schreber) for grazing livestock, development pressure from adja-

cent communities, and the encroachment of woody vegetation (Arkansas Natural Heritage Commission 2004). Due to the prairie's secure ownership and such current management practices as regular use of prescribed fire and the control of exotics, most historical threats have been eliminated. One possible threat to plant species inhabiting Baker Prairie, however, is the potential for reduced genetic fitness due to the geographic isolation of this prairie from other high quality prairies in Arkansas and adjacent states.

Following European settlement and prior to state ownership, haying and grazing were apparently the main management tools used to maintain the prairie (Arkansas Natural Heritage Commission 2004). Beginning in 1992, Baker Prairie Natural Area has been the site of aggressive management efforts that include the removal of encroaching woody vegetation and exotic species; seed collection and planting; brush hogging; herbicide treatment of *Festuca arundinacea*, *Lespedeza cuneata* (Dum.-Cours.) Don, *Lonicera japonica* Thunb., *Carduus nutans* L., *Albizia julibrissin* Durazz, *Daucus carota* L., woody sprouts and stumps; and the use of prescribed fire (Arkansas Natural Heritage Commission 2004). These intensive management efforts have been successful in maintaining the rich botanical diversity of the area and restoring the ecological integrity of the prairie. In addition to *Carex bicknellii*, Baker Prairie provides habitat for other rare plant species tracked as elements of conservation concern by the Arkansas Natural Heritage Commission. These include *Antennaria neglecta* E. Greene, *Aster sericeus* Vent., *Calopogon oklahomensis* D.H. Goldman, *Carex gravida* L. Bailey, *Gentiana puberulenta* J. Pringle, *Nemastylis nuttallii* Picker ex R. Foster, *Silene regia* Sims, *Trillium pusillum* Michaux var. *ozarkanum* (E.J. Palmer & Steyerm.) Steyerm., *Viola pedatifida* G. Don, and *Zizia aptera* (A. Gray) Fern.. Rare animals of conservation concern at the site include ornate box turtle [*Terrapene ornata ornata* (Agassiz)], grasshopper sparrow [*Ammodramus savannarum* (Gmelin)], willow flycatcher [*Empidonax traillii* (Audubon)], and prairie mole cricket (*Gryllotapa major* Saussure).

Voucher Specimens. **U.S.A. ARKANSAS. Boone Co.:** Arkansas Natural Heritage Commission and TNC's Baker Prairie Natural Area in western Harrison, ca. 0.4 km S of the inter. of Industrial Dr. and Goblin Dr.; T18N,R20WS5 SW1/4NE1/4NW1/4; Gaither 7.5' Quad.; N 36° 14'40.2", W 93° 08'01.6" (Datum = NAD83 Zone 15); infrequent in scattered colonies on dry mounds of native prairie; in association with *Baptisia bracteata, Berlandiera texana, Carex bushii, Ceanothus americanus, Commandra umbellata, Euphorbia corollata, Hypoxis hirsuta, Luzula bulbosa, Physalis sp., Schizachyrium scoparium, Silphium integrifolium, S. laciniatum,* and *Tradescantia ohiensis*; 9 May 2005 *Paul M. McKenzie 2187* (MO, MICH, UMO); 10 May 2005 *Theo Witsell 05-0330* (anhc-Arkansas Natural Heritage Commission, UARK, peh-pers. herb. of Philip E. Hyatt); 1 Jun 2003 *Theo Witsell 03-0437* (anhc).

Botanical nomenclature listed herein follows Yatskievych and Turner (1990) except for *Calypogon oklahomensis* that follows Yatskievych (1999), and *Carex bicknellii* and *C. opaca* that follow Rothrock and Reznicek (2001).

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GREEN FRINGED ORCHID (*PLATANTHERA LACERA*, ORCHIDACEAE) IN SOUTHERN LOUISIANA

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ABSTRACT

A new population of *Platanthera lacera* is reported for Vernon Parish, southern Louisiana.

RESUMEN

Se cita una nueva población de *Platanthera lacera* de Vernon Parish, Sur de Louisiana.

Green fringed orchid (***Platanthera lacera*** (Michx.) G. Don) was reported for Louisiana as early as 1852 by Riddell (1852). A specimen was collected in Shreveport in Caddo Parish by MacRoberts in 1976 (MacRoberts 1977). Apparently, this specimen was misidentified and not included in the orchid flora of Louisiana by Prigeon and Urbatsch (1977) and excluded by Thomas and Allen (1993). This species was reinstated to the Louisiana flora by MacRoberts and MacRoberts (1998); the authors also stated that the site for the collection in Caddo Parish was now a housing development. Green fringed orchid is reported from all of the eastern United States except for Florida (USDA, NRCS 2005). In Texas, this orchid is reported only from Bowie County (Correll 1947; Liggio & Liggio 1999).

The habitats reported for this orchid include open sedge swamps and marshes, bogs, meadows, and glades of open woods, swampy woods and wet or occasionally dry open fields and prairies, and in thickets (Correll 1978; Liggio & Liggio 1999; Radford et al. 1968). In Flora of North America Editorial Committee (2002), this species is reported from sphagnum bogs, alluvial and swamp forests, stream banks, riparian meadows, sand flats, moist and seeping slopes, prairies, roadside banks, ditches, old fields, and borrow pits. According to Liggio and Liggio (1999), this orchid has a preference for acidic soils but is indifferent to varying conditions of moisture, sunlight, and shade.

On May 6, 2005, a new population of green fringed orchid was discovered in Vernon Parish, Louisiana which is ca 150 miles south of the Caddo Parish location and apparently the southernmost location in the United States. The collection data are:

Voucher specimen: **LOUISIANA. Vernon Parish:** along edge of mowed hunting trail, edge of pasture and beech/white oak forest in Section 14 T2S R7W, GPS N30.942 W93.053, ca. 1/4 mi SW of Talbert-Pierson Cemetery (Pine Grove Church) and ca. 5 mi NW of Sugartown in drainage of unnamed creek that drains into Whiskey Chitto Creek, 24 May 2005, *Allen et al 19415*, (BRIT, Fort Polk Herb., ULM).

The habitat varied from an open mowed trail to the dense edge of the beech/white oak forest of the creek edge and from moderately well drained to moist soil. The soil type is Gore which is a very fine sandy loam with 5 to 12 percent slopes (Soil Survey Staff 2003). The elevation in the area ranges from 150 to 160 feet. The plants had just begun to flower on May 6, seemed to peak around May 20, and just a very few flowers were noted on June 11, 2005.

During May 2005, the site was revisited several times and 35 clumps of the orchid were noted; most clumps had a single flowering stem but a few had two flowering stems. The area surrounding each of the 35 clumps was examined and the five nearest individuals were identified including herbaceous, woody vine, shrub (woody non-vines shorter than six feet), shrubs/saplings (woody non-vines taller than six feet and five inch or less dbh), and trees (woody non-vines taller than six feet and larger than 5 inch dbh) species (Table 1). The percent of each species out of the 175 total individuals (five times 35) for each category is listed in Table 1; for the herbaceous and woody vines only one percent is reported for each species and for the woody non-vine species, the first percent listed is the shrub, the second is the shrubs/saplings, and third is the trees. The surrounding area was examined for a distance of twenty feet and all associated species were identified and listed in Table 1. A total of 124 species from 90 genera and 56 families were identified as a nearest individual or associated species. Densiometer readings were taken at each clump and the average cover percent was 61.04% and ranged from 43.03% to 75.00%.

The most common occurring nearest herbaceous species was *Chasmanthium sessiliflorum* (Poir.) Yates (17.71%) and was followed by *Dichanthelium dichotomum* (L.) Gould (12.57%), *Sanicula canadensis* L. (8.57%), *Allium canadense* L. (8.00%), and *Dichanthelium laxiflorum* (Lam.) Gould (5.71%). The woody vine species that was most commonly nearest the orchid was *Toxicodendron radicans* (L.) Kuntze (38.29%) and was followed by *Lonicera japonica* Thunb. (37.14%) and *Parthenocissus quinquefolia* (L.) Planch. (12.57%). The most common nearest shrub species was *Rubus argutus* Link (25.71%) and was followed by *Quercus alba* L. (8.57%), *Callicarpa americana* L. (7.43%), and *Quercus hemisphaerica* Bartr. ex Willd. (6.86%). The most common nearest tree species with smaller dbh (5 inch or less) were *Pinus taeda* L. (30.86%) and *Ilex vomitoria* Ait. (12.00%) and with the larger dbh (> 5 inch dbh) were *Liquidambar styraciflua* L. (23.43%), *Triadica sebifera* (L.) Small (20.00%), and *Quercus alba* L. (17.14%).

TABLE 1. List of species associated with 35 clumps of green fringed orchid in Vernon Parish, Louisiana, during May 2005 with percent[1] of nearest individual records.

ACANTHACEAE
Ruellia caroliniensis (J.F. Gmel.) Steud. (1.14%)

ACERACEAE
Acer rubrum L. (5.71%, 1.71%, 1.71%)

ANACARDIACEAE
Toxicodendron radicans (L.) Kuntze (38.29%)

APIACEAE
Ptilimnium capillaceum (Michx.) Raf.
Sanicula canadensis L. (8.57%)

AQUIFOLIACEAE
Ilex opaca Ait. (1.14%, 0, 0)
Ilex vomitoria Ait. (3.43%, 12.00%, 0)

ARACEAE
Arisaema triphyllum (L.) Schott

ARALIACEAE
Aralia spinosa L. (2.29%, 3.43%, 0.57%)

ARISTOLOCHIACEAE
Aristolochia serpentaria L.

ASPLENIACEAE
Asplenium platyneuron (L.) B.S.P.

ASTERACEAE
Elephantopus carolinianus Raeusch. (2.86%)
Helenium flexuosum Raf.
Lactuca canadensis L.
Solidago canadensis L. (4.57%)
Solidago rugosa P. Mill. (1.71%)
Symphyotrichum lateriflorum (L.) A.& D. Löve (2.29%)

BETULACEAE
Carpinus caroliniana Walt. (1.71%, 3.43%, 1.71%)
Ostrya virginiana (P. Mill.) K. Koch (0, 1.14%, 0)

BIGNONIACEAE
Bignonia capreolata L. (3.43%)

CAMPANULACEAE
Lobelia appendiculata A. DC.

CAPRIFOLIACEAE
Lonicera japonica Thunb. (37.14%)
Sambucus nigra L. (2.29%, 2.29%, 0)
Viburnum acerifolium L.
Viburnum dentatum L. (1.14%, 2.29%, 0)

CELASTRACEAE
Euonymus americana L. (0.57%, 0, 0)

CLUSIACEAE
Hypericum hypericoides (L.) Crantz
Hypericum mutilum L.

CORNACEAE
Cornus florida L. (0.57%, 0, 0)

CUPRESSACEAE
Juniperus virginiana L. (0, 0.57%, 0)

CYPERACEAE
Carex complanata Torr. & Hook. (2.86%)
Carex debilis Michx.
Carex digitalis Willd.
Carex festucacea Schkuhr ex Willd.
Carex flaccosperma Dewey (0.57%)
Carex longii Mack. (0.57%)
Carex rosea Willd. (1.14%)
Carex texensis (Torr.) Bailey
Rhynchospora caduca Ell.
Scleria oligantha Michx.

DIOSCOREACEAE
Dioscorea villosa L.

DRYOPTERIDACEAE
Onoclea sensibilis L.
Polystichum acrostichoides (Michx.) Schott.

EBENACEAE
Diospyros virginiana L. (0.57%, 0, 0)

ERICACEAE
Vaccinium arboreum Marsh.
Vaccinium elliottii Chapman (1.14%, 0, 0)

EUPHORBIACEAE
Triadica sebifera (L.) Small (1.14%, 8.00%, 20.00%)

FABACEAE
Galactia volubilis (L.) Britton
Lespedeza cuneata (Dum.-Cours.) G. Don (0.57%)
Trifolium repens L. (0.57%)
Vicia sativa L. ssp. *nigra* (L.) Ehrh. (1.71%;

FAGACEAE
Fagus grandifolia Ehrh. (0, 0.57%, 10.29%)
Quercus alba L. (8.57%, 0.57%, 17.14%)
Quercus hemisphaerica Bartr. ex Willd. (6.86%, 6.86%, 0)
Quercus nigra L. (4.00%, 2.29%, 1.14%)

HAMAMELIDACEAE
Hamamelis virginiana L. (0, 1.71%, 0)

TABLE 1. continued

Liquidambar styraciflua L. (3.43%, 5.14%, 23.43%)

JUGLANDACEAE

Carya alba (L.) Nutt. ex Ell. (0, 0, 0.57%)
Carya glabra (P. Mill.) Sweet var. *hirsuta* (Ashe) Ashe (5.14%, 0, 3.43%)
Carya illinoinensis (Wangenh.) K. Koch

JUNCACEAE

Juncus coriaceus Mack.
Juncus marginatus Rostk. (0.57%)
Juncus polycephalus Michx.
Juncus tenuis Willd. (1.71%)

LAMIACEAE

Pycnanthemum tenuifolium Schrad.
Salvia lyrata L. (0.57%)
Scutellaria elliptica Muhl. ex Spreng. (0.57%)

LAURACEAE

Sassafras albidum (Nutt.) Nees (0.57%, 0, 0)

LILIACEAE

Allium canadense L. (8.00%)
Lilium michauxii Poir.
Polygonatum biflorum (Walt.) Ell.

LINACEAE

Linum striatum Walt.

LOGANIACEAE

Gelsemium sempervirens (L.) St. Hil. (0.57%)

LYCOPODIACEAE

Lygodium japonicum (Thunb. ex Murr.) Sw. (0.57%)

MELIACEAE

Melia azedarach L. (0.57%, 2.29%, 0.57%)

MORACEAE

Morus rubra L. (0.57%, 1.71%, 0)

MYRICACEAE

Morella cerifera (L.) Small (0.57%, 0.57%, 0)

NYSSACEAE,

Nyssa sylvatica Marsh. (4.57%, 0, 4.00%)

OLEACEAE

Chionanthus virginicus L. (0, 0, 0.57%)
Ligustrum sinense Lour. (4.57%, 8.00%, 0)

ONAGRACEAE

Ludwigia alternifolia L.
Ludwigia palustris (L.) Ell.

OROBANCHACEAE

Epifagus virginiana (L.) W. Bart.

OSMUNDACEAE

Osmunda cinnamomea L.
Osmunda regalis L.

OXALIDACEAE

Oxalis stricta L.

PINACEAE

Pinus taeda L. (0, 30.86%, 10.29%)

POACEAE

Andropogon gerardii Vitman (1.14%)
Briza minor L.
Chasmanthium laxum (L.) Yates
Chasmanthium sessiliflorum (Poir.) Yates (17.71%)
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *lindheimeri* (Nash) Gould & C.A. Clark
Dichanthelium boscii (Poir.) Gould & C.A. Clark (4.00%)
Dichanthelium commutatum (J.A. Schultes) Gould (4.57%)
Dichanthelium dichotomum (L.) Gould (12.57%)
Dichanthelium laxiflorum (Lam.) Gould (5.71%)
Leersia virginica Willd.
Lolium perenne L. (2.29%)
Melica mutica Walt.
Oplismenus hirtellus (L.) Beauv. (2.29%)
Paspalum urvillei Steud.
Sphenopholis obtusata (Michx.) Scribn. (0.57%)

RHAMNACEAE

Berchemia scandens (Hill) K. Koch (1.71%)

ROSACEAE

Crataegus marshallii Egglest. (0.57%, 0, 0)
Prunus serotina Ehrh. (0.57%, 0, 0)
Rubus argutus Link (25.71%, 0, 0)
Rubus trivialis Michx. (3.43%, 0, 0)

RUBIACEAE

Galium pilosum Ait.
Galium tinctorium L. (4.00%)
Galium uniflorum Michx.
Mitchella repens L. (2.86%)

SMILACACEAE

Smilax glauca Walt. (2.29%)
Smilax pumila Walt.
Smilax rotundifolia L.

TABLE 1. continued

Smilax smallii Morong
Smilax tamnoides L.

THELYPTERIDACEAE
Thelypteris kunthii (Desv.) Morton

ULMACEAE
Ulmus alata Michx. (1.14%, 2.29%, 2.86%)
Ulmus americana L. (0, 0, 1.71%)

URTICACEAE
Boehmeria cylindrica (L.) Sw.

VERBENACEAE
Callicarpa americana L. (7.43%, 2.29%, 0)

VIOLACEAE
Viola sororia Willd. (1.14%)

VITACEAE
Parthenocissus quinquefolia (L.) Planch. (12.57%)
Vitis rotundifolia Michx. (4.00%)

[1] Percent of nearest individual records = number of nearest plant records divided by 175 and multiplied by 100 for each species category. The categories are herbaceous, woody vine, shrub (woody non-vines shorter than six feet) (first percent), shrubs/saplings (woody non-vines talier than six feet and five inch or less dbh) (second percent), and trees (woody non-vines taller than six feet and larger than 5 inch dbh) (third percent).

ACKNOWLEDGMENTS

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Contents.—Preface, Acknowledgments. **1)** ***Ceanothus*** in the Garden and Landscape (Natural Distribution, History of Cultivation, Growing *Ceanothus*, Disease and Pests, Cultivar Development, Propagation, *Ceanothus* Speciese and Cultivars for the Garden and Landscape, *Ceanothus* Selection Guide. **2)** ***Ceanothus*** in the Wild (Ecological and Geographic Distribution, Form and Function in *Ceanothus*, *Ceanothus* Species, Other *Ceanothus* Names). Conversion Tables, Glossary, Bibliography, Index.

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Robin White. 2006. **Daphnes: A Practical Guide for Gardeners.** (ISBN 0-88192-752-X, 978-0-88192-752-8, hbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax.). $34.95, 232 pp., color photos, 7" × 9".

Contents.—Foreword, Preface, **1)** History, Taxonomy and Morphology. **2)** *Daphne* Species **3)** Daphne Hybrids. **4)** Propagation. **5)** Cultivation. **6)** Pests and Diseases. **7)** Garden Use. Useful Addresses. Glossary, Bibliography, Index of Daphnes, Conversion Tables.

SEYMERIA FALCATA (SCROPHULARIACEAE), A NEW RECORD FOR TEXAS AND THE UNITED STATES

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ABSTRACT

Upon review of herbaria specimens and recent collections, it is clear that *Seymeria falcata* B.L. Turner occurs in the Dead Horse Mountains of southern Brewster County, Texas. This is the first report of this species for Texas and the United States.

RESUMEN

Basándonos en la revisión de especimenes herbario y colecciones recientes está claro que *Seymeria falcata* B.L. Turner ocurre en las Montañas Caballos Muertos en el condado meridional de Brewster, Tejas. Éste es la primera cita de esta especie para Tejas y los Estados Unidos.

Turner (1982) provided a revisional study of the largely Mexican genus *Seymeria*. In this he described *S. falcata* B.L. Turner, a new species then known only from north-central Mexico, partially sympatric with its closest ally *S. scabra* Gray. The latter is typified by material collected by Charles Wright in the Davis Mountains of Jeff Davis County, Texas, and is distinguished by mostly symmetrical, semi-falcate fruits and markedly scabrous stems and foliage. In contrast, *S. falcata* has weakly to decidedly falcate fruits and minutely puberulous or glabrous stems and foliage, and glabrous fruits.

Turner et al. (2003) recognized only a single species of *Seymeria*, *S. scabra*, as occurring in Trans-Pecos Texas. Recent collections from the Dead Horse Mountains in the Sierra Del Carmen of Big Bend National Park have revealed the presence there of *S. falcata*.

Voucher specimens: **TEXAS. Brewster Co.:** Dead Horse Mountains, on rocky ridge above Brushy Canyon, ca. 1/2 mi N of lodge, 1220 m, 15 Aug 1994, *Talbot 137* (SRSC); Dead Horse Mountains, north sister of Sue Peaks at crest, 1740 m, 16 Sep 1994, *Talbot 255* (SRSC); western slopes of Dead Horse Mountains below Sue Peaks, 1420 m, 3 Sep 2005, *Fenstermacher 1187* (SRSC); Dead Horse Mountains, 5 mi in on Telephone Canyon Trail from Old Ore Road, 1310 m, 8 Mar 2005, *Fenstermacher 571* (SRSC).

Seymeria falcata was first collected by Miller Talbot in the Dead Horse Mountains but his 1994 specimen was identified as *Seymeria scabra*. My recent collections of *S. falcata* from the Dead Horse Mountains spurred a review of the *Seymeria* specimens in the SRSC herbarium, thereby discovering and correctly identifying Talbot's previous collection. My *S. falcata* collections were made at

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two locations in relative proximity to Talbot's collection sites, at elevations between 1310 m and 1430 m (*Fenstermacher 571, 1187*, SRSC). I also collected *S. scabra* in a range of elevations in proximity to all collections mentioned here (*Fenstermacher 744D, 1018, 1050*, SRSC). The two species are clearly sympatric and hybridization between the two is suspected (*Fenstermacher 1018, 1050*, SRSC).

ACKNOWLEDGMENTS

I would like to acknowledge the generosity of Billie L. Turner and thank him for bringing this to my attention. Thanks also go to the Sul Ross State University herbarium for research space, holdings, and technical expertise, without which this discovery would not have been made. The two reviewers, Guy L. Nesom and Richard D. Worthington, made helpful suggestions.

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CAYRATIA JAPONICA (VITACEAE) NEW TO NORTH CAROLINA AND AN UPDATED KEY TO THE GENERA OF VITACEAE IN THE CAROLINAS

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ABSTRACT

A population of the introduced and expanding *Cayratia japonica* (Thunb.) Gagnep. (Vitaceae) is reported for North Carolina. Voucher specimens are cited and an updated key to the genera of Vitaceae in the Carolinas is presented.

RESUMEN

Se cita de Carolina del Norte una población de la especie introducida y en expansión *Cayratia japonica* (Thunb.) Gagnep. (Vitaceae). Se dan los pliegos testigo y se presenta una clave puesta al día de los géneros de Vitaceae en las Carolinas.

The Asian vine *Cayratia japonica* (Thunb.) Gagnep. var. *japonica* (Vitaceae) is known from Louisiana, Mississippi, and Texas, but has not been previously reported escaped elsewhere in the United States (Shinners 1964; Brown 1992; Alford 2003; USDA, NRCS 2005). The species was not previously reported for North Carolina by Radford et al. (1968), Pittillo et al. (1969), Pittillo et al. (1972), Kral (1981), Pittillo and Brown (1988), or USDA, NRCS (2005). However, an aggressive and persistent population of the plant was recently encountered on private property in a suburban area near Winston-Salem (Forsyth Co., NC). Vines were growing up trees (reaching heights of 9–12 m high), along a fence, and generally throughout the landscape—covering about 0.5 acre. When visited in late August, the vines were in full flower and well-attended by honeybees and wasps. Based on conversations with the landscaper, individual ramets aggressively re-sprouted following handweeding. Apparently, a vine of > 2.5 cm diam at the base had been removed. Remaining roots at the site were ca. 0.6 cm diam. It remains unclear how the species arrived. Both previous and current homeowners, the latter an avid birdwatcher, indicated that the species had not been planted. However, intentional planting or contamination through other ornamental plantings cannot be ruled out. Bird dispersal may be a possibility, although unlikely as additional populations between North Carolina and the Gulf Coast would be expected under this scenario and reproduction is reported to be primarily vegetative in North America—at least in Texas (Brown 1992).

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Although the vector of arrival remains unknown, the persistence of the North Carolina population is of concern. Alford (2003) reported a Mississippi population tripling in size within 10 months. Little information is currently available regarding control measures.

Voucher specimens: **U.S.A. NORTH CAROLINA. Forsyth Co.:** Wesleyan Lane, Winston-Salem, 11 Aug 2005, *Jonathan Todd s.n.* (NCSC, USCH). Wesleyan Lane, Winston-Salem, 29 Aug 2005, *Robert J. Richardson s.n.* (FLAS, NCSC, USCH).

Cayratia japonica (Fig. 1) can be distinguished from other Vitaceae taxa in the Carolinas by the pedate quinquefoliate leaves. Tendrils are bifurcating and not disk-tipped. An updated key to the genera of Carolina Vitaceae follows. *Cissus* is included here based on the listing of *C. trifoliata* (L.) L. by Weakley (2005). *Cissus trifoliata* is cultivated in North Carolina, but has not been observed to escape (Krings, pers. obs.).

1. Tendrils, at least some, terminating in adhesive disks _____ **Parthenocissus** Planch.
1. Tendrils lacking adhesive disks
   2. Leaves pedate quinquefoliate _____ **Cayratia** Juss.
   2. Leaves simple, palmately, or pinnately compound, but never pedate quinquefoliate.
      3. Inflorescence a thyrse; petals connate at their apices _____ **Vitis** L.
      3. Inflorescence a dichotomous or umbelliform cyme; petals free at their apices.
         4. Cyme dichotomous; flowers 5-merous _____ **Ampelopsis** Michx.
         4. Cyme umbelliform; flowers 4-merous _____ **Cissus** L.

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We thank Jonathan Todd for bringing the Forsyth population to our attention and the curators and staff of DUKE and NCU for access to their collections. Guy Nesom offered helpful review comments.

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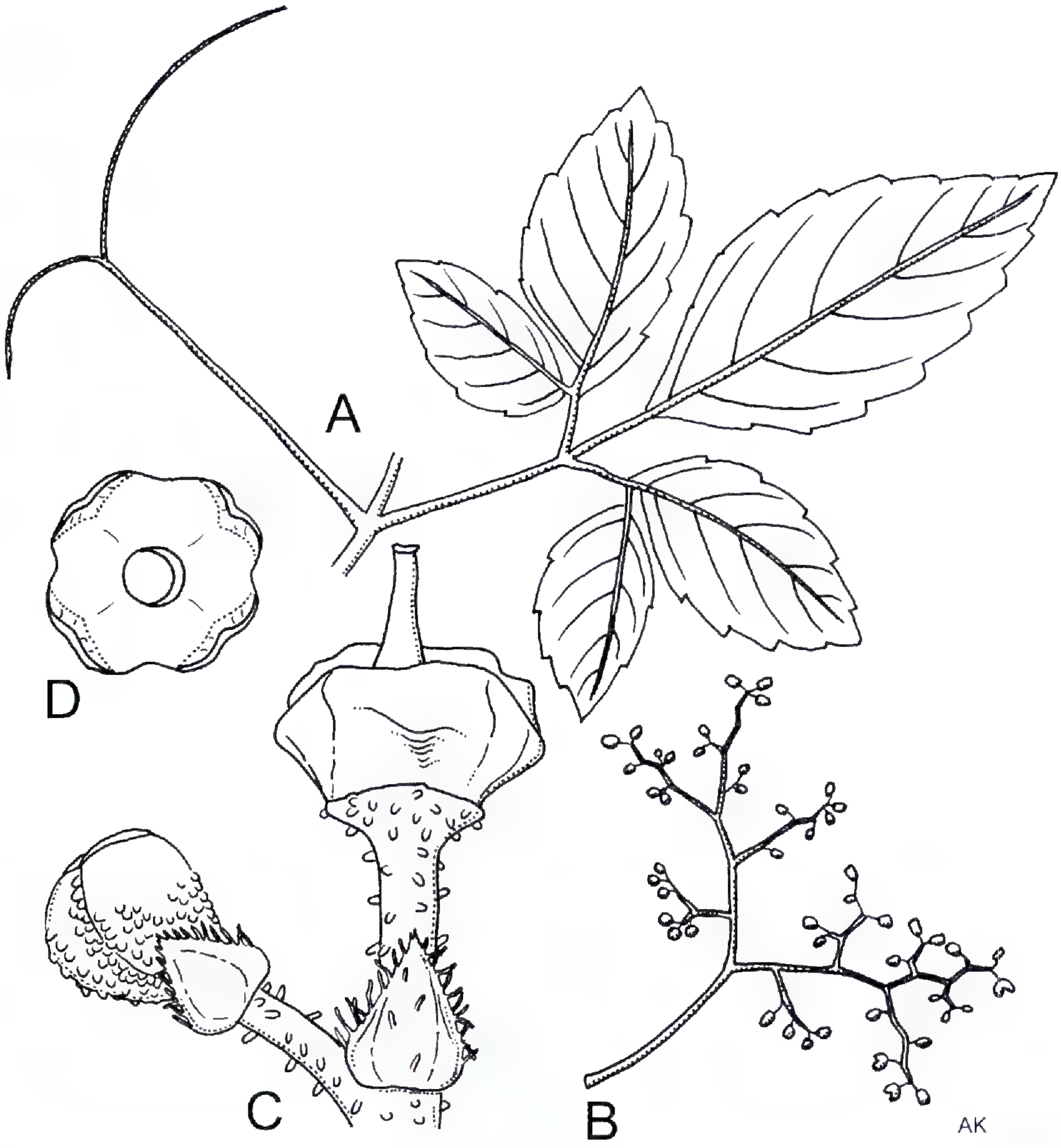


FIG. 1. *Cayratia japonica* (Thunb.) Gagnep.: **A.** Pedate quinquefoliate leaf and bifurcate tendril; **B.** inflorescence; **C.** detail of flower (petals removed) and flower bud; **D.** disk (style removed). Leaf, flower bud, and disk based on *Darwin & Sundell 903* (NCU); tendril and inflorescence based on *Sundell 1580* (NCU).

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Douglas D. Stokke and Leslie H. Groom. 2006. **Characterization of the Cellulosic Cell Wall.** (ISBN 0-8138-0439-6, 978-0-8138-0439-2, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** 515-292-0140, 515-292-3348 fax 1-800-862-6657, www.blackwellprofessional.com, orders@ames.blackwellpublishing.com). $149.99, 274 pp., color photos, numerous b/w illustrations, 7" × 10".

John F. Leslie and Brett A. Summerell. 2006. **The *Fusarium* Laboratory Manual.** (ISBN 0-8138-1919-9, 978-0-8138-1919-8, spiral pbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** 515-292-0140, 515-292-3348 fax 1-800-862-6657, www.blackwellprofessional.com, orders@ames.blackwellpublishing.com). $124.99, 388 pp., b/w illustrations, 8 1/2" × 11".

From the publisher.—For the first time in over 20 years, a comprehensive collection of photographs and descriptions of species in the fungal genus *Fusarium* is available. This laboratory manual provides an overview of the biology of *Fusarium* and the techniques involved in the isolation, identification and characterization of individual species and the populations in which they occur. It is the first time that genetic, morphological and molecular approaches have been incorporated into a volume devoted to *Fusarium* identification. The authors include descriptions of species, both new and old, and provide protocols for genetic, morphological and molecular identification techniques.

NEW AND NOTEWORTHY COLLECTIONS FOR ARKANSAS

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ABSTRACT

Ten species of vascular plants, all native or naturalized in the southeastern United States, are reported as new or noteworthy for Arkansas. Of these, five are native and five are non-native. Seven are reported as state records, and the accounts for the other three species provide clarifications, including updates on the status of two aquatic weeds, one federally listed as an invasive non-native weed (*Hydrilla verticillata*) and another erroneously thought to be native to the United States (*Salvinia minima*). Species reported as a state record are: *Amaranthus blitum, Chamaesyce hypercifolia, Chamaesyce opthalmica, Euphorbia graminea, Hedyotis corymbosa, Ipomoea quamoclit*, and *Parietaria floridana*.

RESUMEN

Se citan diez especies de plantas vasculares, todas nativas o naturalizadas en es sureste de los Estados Unidos, como nuevas o notables para Arkansas. De estas, cinco son nativas y cinco no nativas. Siete se citan para el estado, y para las otras tres especies se aportan clarificaciones, incluyendo puestas al día del estatus de dos plantas acuáticas, una de ellas del listado federal de plantas invasoras no nativas (*Hydrilla verticillata*) y otra que se pensó erróneamente que era nativa de los Estados Unidos (*Salvinia minima*). Las especies citadas como nuevas para el estado son: *Amaranthus blitum, Chamaesyce hypercifolia, Chamaesyce opthalmica, Euphorbia graminea, Hedyotis corymbosa, Ipomoea quamoclit*, y *Parietaria floridana*.

INTRODUCTION

The Arkansas Vascular Flora Project is an on-going collective effort to produce a complete and modern treatment to the vascular flora of Arkansas in the form of a checklist, atlas, and manual (Peck 2003). Toward that end, urban and rural parks, transportation routes, and other ruderal areas in Pulaski Co. and elsewhere in central Arkansas were surveyed to test the completeness of the floristic record. The state occurrence and state county distribution of species collected was determined from dot-maps kept at Herbarium LRU, University of Arkansas at Little Rock. The national occurrence and distribution of the new state records was determined from the national flora database kept by NRCS (1999). Records at the state and county level were documented with herbarium specimens. The records reported here support the notion that lesser quality habitats, such as urban and rural disturbed or ruderal habitats, whether xeric ones along railroad tracks or aquatic ones such as mudflats along impoundments, are under-collected. Although less pristine and aesthetic than non-an-

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thropogenic habitats, ruderal environments warrant further survey in Arkansas to ensure completeness of the floristic record.

SPECIES NEW OR NOTEWORTHY FOR ARKANSAS

Amaranthus blitum L. (Amaranthaceae). Purple amaranth, a US non-native, occurs across the coastal states from Massachusetts south to Florida and west to Louisiana and Texas. This is the first documentation of this species in Arkansas.

Voucher specimen: **Pulaski Co.:** urban ruderal habitat, along railroad tracks at University Ave. and 65th St., Little Rock, 13 Oct 2001, *Peck 2001231* (LRU).

Chamaesyce hirta (L.) Millsp. (Euphorbiaceae). Pillpod sandmat occurs across the coastal states from South Carolina south to Florida and west to Louisiana and Texas. Known from Bradley and Pope Cos., Arkansas. This is the third documentation of this species in Arkansas.

Voucher specimens: **Pulaski Co.:** urban ruderal habitat along railroad tracks at University Ave. and 65th St., Little Rock, 11 Nov 2001, *Peck 20014892, 2001499, 20014895, 2001503* (LRU).

Chamaesyce hypercifolia (L.) Millsp. (Euphorbiaceae). Graceful sandmat occurs across the southeastern United States west to Louisiana and Texas. This is the first documentation of this species in Arkansas.

Voucher specimens: **Pulaski Co.:** urban ruderal habitat along railroad tracks at University Ave. and 65th St., Little Rock, 10 Nov 2001, *Peck 2001490, 2001496, 2001500, 2001504* (LRU).

Chamaesyce opthalmica (Pers.) Burch (Euphorbiaceae). Florida hammock sandmat occurs in Georgia and Florida west to Louisiana. This is the first documentation of this species in Arkansas.

Voucher specimens: **Pulaski Co.:** urban ruderal habitat along railroad tracks at University Ave. and 65th St., Little Rock, 10 Nov 2001, *Peck 2001488, 2001497, 2001502* (LRU).

Euphorbia graminea Jacq. (Euphorbiaceae). Grassleaf spurge, a US non-native, occurs as escapes in Florida and Hawaii. This is the first documentation of this species in Arkansas.

Voucher specimens: **Pulaski Co.:** urban ruderal habitat, along railroad tracks at Barton state fair grounds, Roosevelt Rd., Little Rock, 11 Nov 2001, *Peck 2001567* (LRU); ruderal habitat near railroad tracks, east of University Ave. at 65th St., Little Rock, 4 Sep 1999, *Peck 99764* (LRU).

Hedyotis corymbosa (L.) Lam. [Oldenlandia corymbosa L.] (Rubiaceae). Flat-top mille graines is a coastal species from South Carolina south to Florida and west to Louisiana and Texas. This is the first documentation of this species in Arkansas.

Voucher specimens: **Jefferson Co.:** urban ruderal habitat, along railroad tracks at Old 167 in Pine Bluff near Arkansas River, 14 Oct 2001, *Peck 2001243*. **Pulaski Co.:** ruderal habitat, along railroad tracks at University Ave. and 65th St., Little Rock, 13 Oct 2001, *Peck 2001232* (LRU). **Saline Co.:** ruderal habitat, along railroad tracks, S side of Benton, 13 Oct 2001, *Peck 2001236* (LRU).

Hydrilla verticillata (L. f.) Royle (Hydrocharitaceae). Waterthyme, United States non-native and an aggressive invasive species in the southeastern United States, especially from Florida west to Texas, was first documented from Arkansas by Parker and Serviss (2003). The present collections further document the spread of this species downstream along the Ouachita River impoundments to other counties in central Arkansas.

Voucher specimens: **Garland Co.:** stranded on mudflat by drawdown event of Ouachita River, shoreline at boat ramp park at N side of Carpenter Dam, Lake Hamilton, 23 Nov 2004, *Peck 2004248* (LRU); stranded on mudflat by drawdown event of Ouachita River, shoreline at Spencer's Bay, mouth of Gulpha Creek, Lake Catherine, 23 Nov 2004, *Peck 2004240* (LRU); stranded on mudflat by drawdown event on Ouachita River, Lake Ouachita, shoreline at Brady Mountain campground, end of CR 119, 9 Dec 2004, *Davis s.n.* (LRU). **Hot Spring Co.:** stranded on mudflat by drawdown event of Ouachita River, shoreline of Lake Catherine, Lake Catherine State Park, 23 Nov 2004, *Peck 2004243* (LRU). **Montgomery Co.:** stranded on mudflat by drawdown event of Ouachita River, shoreline at Big Fir Campground, Lake Ouachita, end of CR 56, 23 Nov 2004, *Peck 2004262* (LRU).

Ipomoea quamoclit L. (Convolvulaceae). Cypressvine is native to tropical America, but is known to escape from cultivation across the southeastern United States, and is known from all states surrounding Arkansas. This collection documents the first occurrence of this species in Arkansas.

Voucher specimen: **Pulaski Co.:** urban ruderal habitat, present for three years as escape at informal dumping grounds along railroad tracks at Barton state fair grounds, Roosevelt Rd., Little Rock, 14 Nov 2005, *Peck 2005009* (LRU).

Parietaria floridana Nutt. (Urticaceae). Florida pellitory is a coastal species that occurs from Delaware south to Florida and west to Louisiana and Texas. This is the first documentation of this species in Arkansas.

Voucher specimens: **Garland Co.:** ruderal habitat along roadside, 4 mi E Hot Springs on 270, 22 May 2002, *Peck 2002043* (LRU). **Grant Co.:** ruderal habitat along roadside, 3 mi E Poyen, 22 May 2002, *Peck 2002032* (LRU). **Hot Spring Co.:** ruderal habitat along roadside, 4 mi S Malvern on 9, 22 May 2002, *Peck 2002043* (LRU). **Pulaski Co.:** urban ruderal habitat along roadside in Boyle Park, Little Rock, 22 May 2002, *Peck 2002018 (LRU)*. **Saline Co.:** ruderal habitat along roadside, 4 mi S Benton on 25, 22 May 2002, *Peck 2002054* (LRU).

Salvinia minima Baker (Salvinieaceae). Least waterspangles, a non-native US aquatic fern, occurs in the southeastern United States from South Carolina south to Florida and west to Louisiana and Texas (Peck, 2002). The species was first documented from Arkansas by Peck (1999, 2002). These recent collections document a westerly range extension to three counties in west-central Arkansas.

Voucher specimens: **Garland Co.:** stranded on mudflat by drawdown event of Ouachita River, shoreline at boat ramp park at N side of Carpenter Dam, Lake Hamilton, 23 Nov 2004, *Peck 2004250* (LRU); stranded on mudflat by drawdown event of Ouachita River, shoreline at Spencer's Bay, mouth of Gulpha Creek, Lake Catherine, 23 Nov 2004, *Peck 2004242* (LRU); stranded on mudflat by drawdown event on Ouachita River, Lake Ouachita, shoreline at Brady Mountain Campground, end of CR 119, 23 Nov 2004, *Peck 2004260* (LRU). **Hot Spring Co.:** stranded on mudflat by drawdown event of Ouachita River, shoreline of Lake Catherine, Lake Catherine State Park, 23 Nov 2004, *Peck 2004245*

(LRU). **Montgomery Co.:** stranded on mudflat by drawdown event of Ouachita River, shoreline at Big Fir Campground, Lake Ouachita, end of CR 56, 23 Nov 2004, *Peck 2004264* (LRU).

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CLEMATIS MOREFIELDII (RANUNCULACEAE) NEW TO TENNESSEE

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ABSTRACT

Clematis morefieldii (Morefield's leather flower, Huntsville vasevine), a federally endangered species, is documented for the flora of Tennessee for the first time. Eighteen plants were discovered along a small rocky ravine positioned on the lower slopes of the western escarpment of the Cumberland Plateau in Franklin County, Tennessee. A general description of the habitat and associated flora is included.

RESUMEN

Clematis morefieldii (flor de cuero de Morefield,), especie en peligro, se documenta para la flora de Tennessee por primera vez. Se descubrieron dieciocho plantas a lo largo de un pequeño barranco en las laderas inferiores del escarpe occidental del Cumberland Plateau en Franklin County, Tennessee. Se incluye una descripción general del hábitat y de la flora asociada.

INTRODUCTION

Clematis morefieldii Kral (Morefield's leather flower, Huntsville vasevine) is a federally endangered species previously thought to be endemic to Madison and Jackson counties, Alabama (Kral 1987; USFWS 1992; Pringle 1997). This relatively recently described species (Kral 1987) is similar to the widespread *C. viorna* but differs from all variants of that species in the cobwebby tomentose to villous pubescence of its stems, and in having bracts at or very near the base of the peduncle rather than well above the base (Pringle 1997). *Clematis morefieldii* also usually differs from *C. viorna* in having more flowers clustered in the leaf axils on shorter peduncles, in its sepals more pinkish and greenish-tinged, and abaxial leaf surfaces more densely pubescent (Kral 1987).

As of 2003, *C. morefieldii* had been documented from ca. 10 populations, and currently at least two of these (including the type locality) are considered extirpated. All known *C. morefieldii* sites occur along the dissected western escarpment of the Cumberland Plateau in rocky limestone woods on mostly south or southwest-facing slopes. These sites are typically dominated by *Juniperus virginiana* L. and various hardwood species characteristic of basic soils, including *Cotinus obovatus* Raf., which is a key indicator species for *C. morefieldii* (Kral

1987). This habitat type, referred to by Kral (1987) as the *Cotinus* association, is restricted to the lower slopes of the western escarpment of the Cumberland Plateau in northeastern Alabama and southeastern middle Tennessee. Kral (1987) suggested that further field exploration of suitable habitats within this community type in Alabama and Tennessee could result in the discovery of additional populations.

In spring 2003, we began searching for *C. morefieldii* in southeastern middle Tennessee close to the nearest known Alabama population of *C. morefieldii*. On 5 Jun 2003, we discovered a small population of *C. morefieldii* in Franklin County, Tennessee ca. 12.5 km northeast of the nearest Alabama population. This is the first report for *C. morefieldii* from Tennessee.

Voucher specimen: **Franklin Co.:** ca. 4.2 mi SE of Huntland (Beans Creek Quad), SE of Motlow Cove in headwaters of Wilhite Creek, N side of Blooin Hollow, growing along small seasonal stream in rocky limestone woods, 5 Jun 2003, *D. Estes & C. Fleming 04795* (TENN).

DISCUSSION

The Franklin County, Tennessee site is on private property approximately 6 km ESE from the town of Huntland on the dissected western escarpment of the Cumberland Plateau in the Elk River watershed of the Tennessee River Basin. The population is located along the lower portion of a SSW-facing slope over Monteagle limestone at an elevation of ca. 347 m (1140 ft). Eighteen plants, one in flower and one with immature fruit, were found. Most of the vines were 0.5 m or less in length and apparently damaged by insect herbivory. The individuals were scattered along a 20 m reach of a wet weather conveyance 1–2 m in width, growing both along the banks and among the boulder substrate within the channel. The surrounding forest contained the following associates: *Acer saccharum* Marsh., *Carya carolinae-septentrionalis* (Ashe) Engl. & Graebn., *Celtis tenuifolia* Nutt., *Fraxinus americana* L., *F. quadrangulata* Michx., *Quercus muehlenbergii* Engelm., *Juniperus virginiana* L., *Cotinus obovatus*, *Cercis canadensis* L., *Ostrya virginiana* (P. Mill.) K.Koch, *Forestiera ligustrina* (Michx.) Poir., *Hamamelis virginiana* L., *Hypericum frondosum* Michx., *Rhus aromatica* Ait., *Bumelia lycioides* (L.) Pers., *Symphoricarpos orbiculatus* Moench, and the rare *Neviusia alabamensis* Gray and *Viburnum bracteatum* Rehd. The most common herbaceous taxa observed were *Dasistoma macrophylla* (Nutt.) Raf., *Polymnia canadensis* L., *Scutellaria ovata* Hill, and *Solidago auriculata* Shuttlw. ex Blake.

Several species considered rare in Tennessee were discovered growing with or adjacent to the *Clematis* population, including a small population of the state-endangered (TNHP 2004) *Viburnum bracteatum* (*Estes & Fleming 04788* TENN). One shrub was growing at the edge of the wet weather conveyance containing *C. morefieldii* and another group of 15–20 individuals were ca. 100 m

away along the rocky banks of a nearby stream. This species is extremely rare throughout its range and is endemic to a small area centered on the Cumberland Plateau of northeastern Alabama, northwestern Georgia, and southeastern Middle Tennessee. This is the second reported Tennessee occurrence for *V. bracteatum* (C. Bailey, Tennessee Natural Heritage Program, pers. comm.). Outside of Tennessee, the species is only known from ca. eight extant populations. There is one each in Floyd and Walker counties in Georgia (J. Allison, Georgia Natural Heritage Program, pers. comm.), and six documented populations in Alabama (Etowah, Jackson, and Madison counties), although one of these has not been observed in more than 50 years (M. Barbour, Alabama Natural Heritage Program, pers. comm.).

Another significant find at the site was a small population of the state-threatened (TNHP 2004) *Neviusia alabamensis* (*Estes & Fleming 04790* TENN). Approximately 30–40 stems were located along a rocky streambank in association with *C. morefieldii*. The *Neviusia*, like the *Clematis*, was visibly impacted by herbivory. Our collection represents a new county record for *N. alabamensis* in the state and the first report for the species from the Tennessee portion of the Cumberland Plateau; however, other populations are known from the Cumberland Plateau of Alabama (Long 1989; D. Estes, pers. obs.) and Georgia (Long 1989). There are nine previously reported Tennessee populations (C. Bailey, Tennessee Natural Heritage Program, pers. comm.) within the Central Basin Section or at the transition zone between the Central Basin and Highland Rim Sections of the Interior Low Plateaus (ILP) Physiographic Province (Horn & Somers 1981; Long 1989). The Franklin County station is ca. 18 km southeast of the nearest previously known Tennessee population in Moore County.

Other rare taxa tracked by the Tennessee Natural Heritage Program (2004) found within 100 m of the *C. morefieldii* site were *Juglans cinerea* L. (Tennessee threatened), *Lonicera dioica* L. (Tennessee threatened), *Solidago auriculata* (Tennessee threatened), and *Cotinus obovatus* (Tennessee special concern). The *Cotinus* and *Solidago* were common components of the forest while only one individual was found of *J. cinerea* and *L. dioica*, respectively.

SUMMARY

The recent discovery of *C. morefieldii* in Tennessee not only represents a state record but also extends the range of the species by some 12.5 km to the northeast. Recent fieldwork in the area has revealed several sites with suitable habitat for *C. morefieldii* on the western escarpment of Tennessee's Cumberland Plateau from the Alabama state line northeastward to southern Warren County. Systematic surveying in this area might result in the discovery of more populations of the federally endangered Morefield's leather flower as well as a number of other significant rare taxa.

ACKNOWLEDGMENTS

Our sincere gratitude is extended to Drs. Robert Kral and Michael Dennis for confirming our identification of *C. morefieldii*. Furthermore, we appreciate the information provided to us by Steve Threlkeld of the Alabama Department of Conservation and Natural Resources, Al Schotz and Michael Barbour of the Alabama Natural Heritage Program, James Allison of the Georgia Natural Heritage Program, and Claude Bailey of the Tennessee Division of Natural Heritage. Thanks are also due to Dan Spaulding, curator of collections at the Anniston Museum of Natural History, who loaned us specimens of Morefield's leather flower from the nearest Alabama population. Dr. B. Eugene Wofford, curator of the University of Tennessee Herbarium, was very helpful throughout the project and his editorial comments improved the manuscript. We wish to thank the Department of Botany at the University of Tennessee for supporting the travel costs associated with this project.

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GRATIOLA BREVIFOLIA (PLANTAGINACEAE) NEW TO THE FLORA OF DELAWARE, THE DELMARVA PENINSULA, AND THE MID-ATLANTIC

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ABSTRACT

Gratiola brevifolia (Plantaginaceae) is reported as a rare and native addition to the flora of Delaware, the Delmarva Peninsula, and to the Mid-Atlantic. This species is disjunct approximately 835 km (520 mi) from the closest known population in Burke Co., Georgia.

RESUMEN

Gratiola brevifolia (Plantaginaceae) se cita como una especie native rara para añadir a la flora de Delaware, la Península de Delmarva, y as to the Mid-Atlantic. Esta especie está disyunta 835 km (520 mi) aproximadamente de la población conocida más cercana en Burke Co., Georgia.

The genus *Gratiola* L. (Plantaginaceae) consists of ca. 30 species (Estes, unpublished data) widely distributed through the North and South Temperate zones and on mountains within the Tropics (Pennell 1935). Six species of *Gratiola* (s.l.) have been reported on the Delmarva Peninsula (Tatnall 1946, McAvoy 2001), an area that lies entirely within the Atlantic Coastal Plain Physiographic Province of the eastern United States and consists of the Eastern Shores of Maryland and Virginia and the majority of the state of Delaware. The northern portion of Delaware lies within the Piedmont Physiographic Province (Plank & Schenck 1998). These six species are *G. aurea* Muhl., *G. neglecta* Torr., *G. pilosa* Michx., *G. ramosa* Walt., *G. virginiana* L., and *G. viscidula* Pennell. On Delmarva, *G. pilosa* and *G. virginiana* are considered to be common, *G. aurea* and *G. neglecta* infrequent, and *G. ramosa* and *G. viscidula* are thought to be historical, having not been reported for 20 or more years (McAvoy, pers. comm.). *Gratiola ramosa* was last collected from Wicomico Co., Maryland, near the town of Salisbury (*Canby s.n.* PH), and *G. viscidula* was last collected from New Castle Co., Delaware, near the city of Wilmington (*Tatnall s.n.* DOV; *Commons s.n.* DOV).

On 23 June 1992, Frank Hirst and Ron Wilson reportedly rediscovered *Gratiola ramosa* in Sussex Co, Delaware (*R. Wilson 0719941*, pers. herbarium). Recently, this population was visited by the first author and specimens were collected and sent to the second author for verification. Subsequently, the speci-

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mens were determined not to be *G. ramosa* but instead were identified as *G. brevifolia* Raf., a species not previously reported from Delaware, the Delmarva Peninsula, or the Mid-Atlantic. Though *G. brevifolia* and *G. ramosa* are easily distinguished by the presence or absence of two bracteoles at the base of the calyx (Godfrey & Wooten 1981), Hirst and Wilson's misidentification could be expected because *G. brevifolia* is not included in any manual commonly used in the Mid-Atlantic (i.e., Fernald 1950; Radford et. al 1968; Brown & Brown 1984; Gleason & Cronquist 1991).

Voucher Specimen: **U.S.A. DELAWARE. Sussex Co.**: Coastal Plain Physiographic Province, ditched portions of Tussocky Branch paralleling Piney Branch Rd., northwest of the town of Delmar, 29 Jul 2005, *Knapp 1549* (DOV, TENN, Maryland Natural Heritage Program Herbarium).

Gratiola brevifolia is an erect perennial of wet, sandy pinelands (Pennell 1935), oak barrens (Tennessee), and sandy riverbanks (Arkansas and Oklahoma). The species ranges from Tennessee and Florida west to Oklahoma and Texas (Pennell 1935) and is found in four centers of distribution, with two occurring east and west of the Mississippi (Fig. 1). Eastward, *G. brevifolia* is centered on the Coastal Plain of northern Florida and southern Georgia with scattered populations west to southeastern Alabama. The species is also significantly disjunct to the Highland Rim and Cumberland Plateau of central Tennessee (Chester et al. 1997). To the west, *G. brevifolia* is most frequent in the West Gulf Coastal Plain of southeastern Texas and southwestern Louisiana, with disjunct populations in the West Gulf Coastal Plain of southeastern Oklahoma and the Ouachita Province of Oklahoma and Arkansas (Estes, unpublished data). Despite the broad geographic distribution, it is considered imperiled in Arkansas (NatureServe Explorer 2005) and probably should be considered a species of conservation concern in Alabama, Oklahoma, and Tennessee (Estes, unpublished data).

McAvoy (2001) listed *Gratiola ramosa* as a species of conservation concern for Delaware based upon the discovery and identification by Hirst and Wilson. With this publication, *G. ramosa* should no longer be considered a component of Delaware's native flora; however, it was historically a component of Delmarva's native flora based on Canby's collection cited above.

The population of *Gratiola brevifolia* in Delaware consists of ca. 1500 individuals restricted to the lower banks and bottoms of a ditched perennial stream. Interestingly, several other species in the vicinity of the *G. brevifolia* population are considered rare in Delaware, based on McAvoy (2003). These species include: *Amphicarpum purshii* Kunth, *Hypericum adpressum* Raf. ex W.Bart., *H. denticulatum* Walt., *Sabatia difformis* (L.) Druce, and *Utricularia radiata* Small.

The discovery of *Gratiola brevifolia* in Delaware marks a new addition to the flora of Delaware, the Delmarva Peninsula, and the Mid-Atlantic region, and is significantly disjunct from all other known populations in the Southeast. The closest population to the Delaware occurrence is ca. 835 km (520 mi)

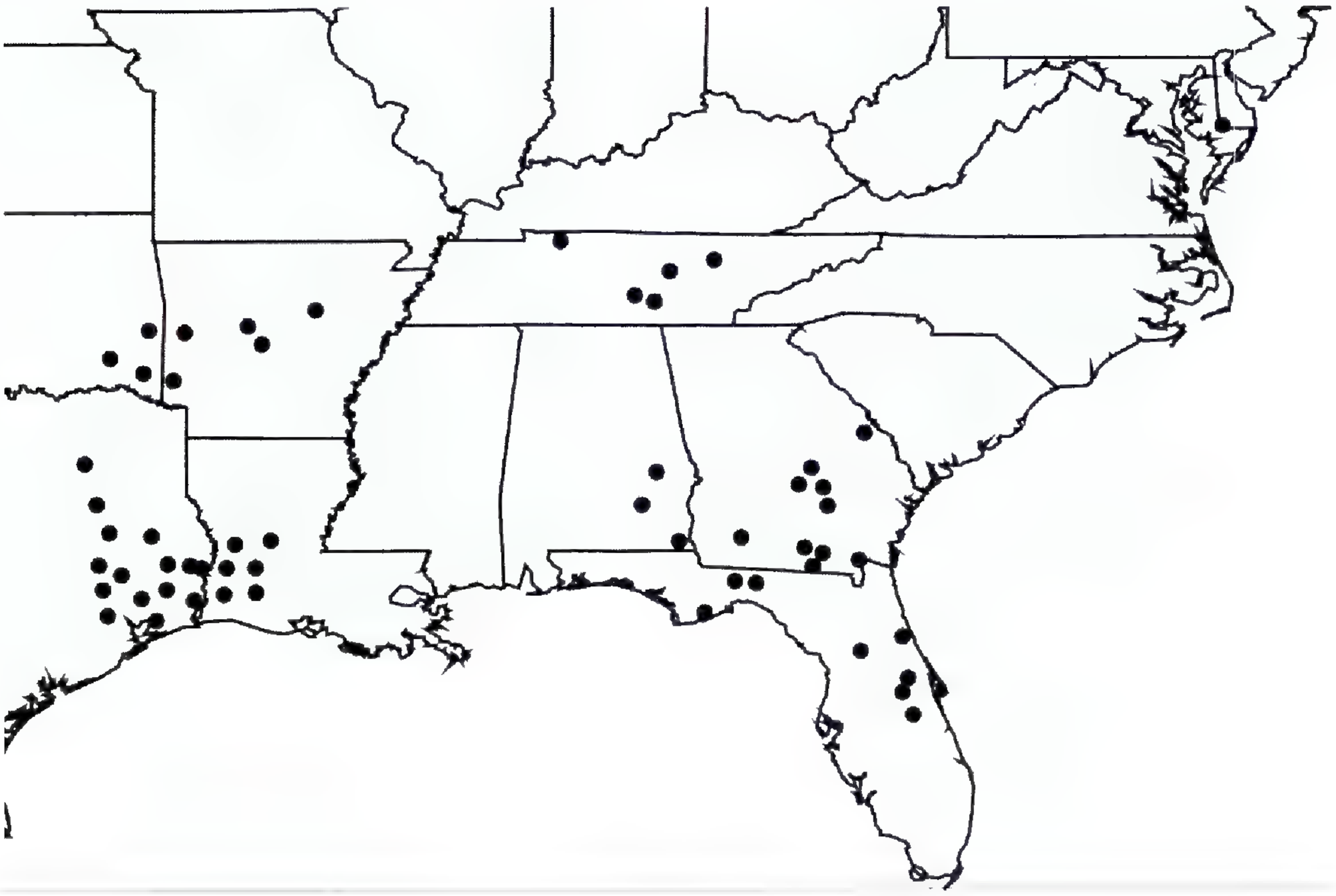


FIG. 1. Range of *Gratiola brevifolia*. Each ● represents a specimen examined.

to the southwest in Burke Co., Georgia (*E.T. Wherry s.n.* PH). Various sources have attributed South Carolina to the range of *G. brevifolia* (NatureServe Explorer 2005; South Carolina Plant Atlas 2005; USDA 2005; Weakley 2005), based upon specimens from Clarendon (*J.F. Townsend 384* CLEMS), Lee (*C.A. Aulbach-Smith 4070* and *4077* with *S. Hutto* USCH), and York counties (*J.B. Nelson 8211 with L. Lundquist* USCH), South Carolina, but these specimens, however, have been annotated by either Deborah Lewis or the second author as *G. ramosa* (Clarendon County) or *G. viscidula* (Lee and York counties).

The nativity of discoveries, such as this, are highly debatable, and entire papers have been devoted to the topic (Lamont & Young 2005). We consider *G. brevifolia* a native component of the flora of Delaware, the Delmarva, and the Mid-Atlantic region for several reasons. First, though the habitat supporting the species in Delaware is highly degraded, *G. brevifolia* is found in similar habitats in other portions of its range. Second, two other species of *Gratiola*, *G. ramosa* and *G. viscidula*, once reached their northern range limits on the Delmarva Peninsula. The historic Maryland population of *G. ramosa* was also significantly disjunct, ca. 500 km (300 mi), from its closest known occurrence in Hoke Co., North Carolina (Radford et al. 1968). Third, the genus *Gratiola* is known for having strange and highly disjunct distributional patterns. For instance, De Lange (1997) reported *G. pedunculata* R.Br. as a new addition to the

flora of New Zealand and considered the species to be a recent natural migrant likely distributed by vagrant birds from mainland Australia, a disjunction of ca. 2150 km (1332 mi). Furthermore, *G. virginiana*, a species primarily distributed in the southeastern United States, is disjunct to the states of Veracruz and Puebla, Mexico from central Texas, a distance of more than 900 km (525 mi) where it occurs in association with other species characteristic of the temperate southeastern United States (Miranda & Sharp 1950). Even *G. brevifolia* has a fragmented range characterized by wide disjunctions. For example, on the Gulf Coastal Plain, the easternmost population of *G. brevifolia* west of the Mississippi River in Rapides Parish, Louisiana is separated by ca. 623 km (387 mi) from the westernmost population east of the Mississippi River in Pike Co., Alabama. Lastly, *G. brevifolia* is not known to be cultivated or grown for horticultural purposes; therefore, it is highly unlikely that this species would have been introduced from nearby cultivated plants.

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Book Notices

University of California

Melinda A. Zeder, Daniel G. Bradley, Eve Emshwiller, and Bruce D. Smith. 2006. **Documenting Domestication: New Genetic and Archaeological Paradigms.** (ISBN 978-0-520-24638-6, hbk.). University of California Press, California/Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A. (**Orders:** www.ucpress.edu/, 609-883-1759, 609-883-7413 fax). $70.00, 361 pp., b/w photos, illustrations, 8 1/2" × 11".

The book is divided into four sections: **1)** Archaeological Documentation of Plant Domestication. **2)** Genetic Documentation of Plant Domestication. **3)** Archaeological Documentation of Animal Domestication. **4)** Genetic Documentation of Animal Domestication.

From the Publisher.—Agriculture is the lever with which humans transformed the earth over the last 10,000 years and created new forms of plant and animal species that have forever altered the face of the planet. In the last decade, significant technological and methodological advances in both molecular biology and archaeology have revolutionized the study of plant and animal domestication and are reshaping our understanding of the transition from foraging to farming, one of the major turning points in human history. This groundbreaking volume for the first time brings together leading archaeologists and biologists working on the domestication of both plants and animals to consider a wide variety of archaeological and genetic approaches to tracing the origin and dispersal of domesticates. It provides a comprehensive overview of the state of the art in this quickly changing field as well as reviews of recent findings on specific crop and livestock species in the Americas, Eurasia, and Africa. Offering a unique global perspective, it explores common challenges and potential avenues for future progress in documenting domestication.

M. Nevin Smith. 2006. **Native Treasures: Gardening with the Plants of California.** (ISBN 0-520-24425-7, pbk.). University of California Press, California/Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A. (**Orders:** www.ucpress.edu/, 609-883-1759, 609-883-7413 fax). $24.95, 278 pp., color photos, 7" × 10".

From the Publisher.—The author explains how California's diverse terrain, climate, and geology support a wealth of plant species—more than 6000—and offers suggestions for designing with most of the major natives in cultivation, as well as with some more obscure but garden-worthy groups. With an engaging narrative and a wealth of illustrations, this ode to beauty and diversity celebrates California's rich store of native plants and encourages readers to visit them in their native haunts and invite them into their gardens.

HEDYOTIS AUSTRALIS (RUBIACEAE) NEW TO MISSOURI AND FLORIDA AND RELATED SPECIES IN THE SOUTH-CENTRAL UNITED STATES

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ABSTRACT

The distribution of white-flowered *Hedyotis australis* is extended to Missouri and Florida as well as within Alabama, Arkansas, Mississippi, and Tennessee. This distribution is compared to allied homostylous species *H. crassifolia* and *H. rosea* which also flower as winter annuals in the south-central United States. *Hedyotis crassifolia* is a diploid species having a flowering peak earlier than the tetraploid *H. australis*. An example of possible out-crossing within *H. crassifolia* via bee pollination is discussed. *Hedyotis rosea* is now considered extirpated in Missouri.

RESUMEN

Hedyotis australis de flores blancas se encuentra distribuida por Missouri y Florida así como también en Alabama, Arkansas, Mississippi, y Tennessee. Su distribución se compara la de las otras especies homostilas *H. crassifolia* y *H. rosea* las cuales florecen como anuales de invierno en la región centro-sur de Estados Unidos. La especie diploide *Hedyotis crassifolia* tiene un pico de floración más temprano que la especie tetraploide *H. australis*. Se discute un ejemplo de posible entrecruzamiento dentro de *H. crassifolia* vía polinización por abejas. *Hedyotis rosea* se considera ahora extinguida en Missouri.

INTRODUCTION

Three winter annual and homostylous bluets (*Hedyotis* or *Houstonia*) flower and fruit in the south-central U.S. largely between January and April. The most common and widely distributed of these is the purple- or violet-colored *Hedyotis crassifolia* Raf. (*Houstonia pusilla* Schöpf). Less well-known is a smaller annual with tiny white corollas which is easily overlooked even when flowering in the same habitat and at the same time as *H. crassifolia*. Consequently, this southern white-flowered *Hedyotis australis* W.H. Lewis & D.M. Moore [*Houstonia micrantha* (Shinners) Terrell] is infrequently collected even when common. A third very small bluet with large pink- or rose-colored corollas, *Hedyotis rosea* Raf. [*Houstonia rosea* (Raf.) Terrell], is more narrowly distributed and occurs in eastern Texas, Louisiana, central and southern Arkansas, western Mississippi, and southeastern Oklahoma, with outlying populations in Alabama (Tuscaloosa Co.) and in 1931 southeastern Missouri (Dunklin Co.).

During March 2005, collections were made of these species concentrating on areas where *H. australis* was unreported but could be expected to occur. Find-

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ing these small bluets by their distinct flower colors of purple-violet, white, and pink-rose is one of the best ways to identify them. In addition, corolla tubes of *H. australis* are short with calyx lobes as long as or longer than the tubes (Fig. 1), while lobes of *H. crassifolia* are much shorter than its longer tubes. However, without these floral characters their discovery is greatly limited even when growing side by side as they often do, and particularly since anthesis is confined to a few weeks at most. All collections were made by *Walter H. Lewis* and *Memory Elvin-Lewis*; their numbers and herbaria of deposit are provided for each collection cited. Many additional ones are at MO.

Cytological differences also exist between these species: *H. crassifolia* is diploid, 2n = 2*x* = 16, *x* = 8, *H. australis* is tetraploid, 2*n* = 4*x* = 32, *x* = 8, and *H. rosea* is diploid, 2*n* = 2*x* = 14, *x* = 7, a reduced base number from the others. That chromosomal reductions, and to some extent polyploidy, have played important roles in the evolution of these and other North American species of *Hedyotis* (Lewis 1965) is supported by recent molecular phylogenetic analyses by Church (2003) who further found that "*Houstonia* is not distinct from either North American *Hedyotis* or *Stenaria*." Additional research is needed for North American (including Mexican) taxa and others worldwide before generic- and tribal-level complexes of both the Hedyotideae and Spermacoceae are satisfactorily resolved. Clearly, this paper does not provide additional data regarding classification and phylogeny, for it is intended only to extend certain species distributions and comment briefly on specific ecologic and reproductive observations.

To aid the reader in identifying the three species, as well as two forms of *H. crassifolia*, f. *crassifolia* and f. *albiflora* (Standley) W.H. Lewis, characters were obtained from Lewis (1970), Smith (1988), Terrell (1996), and herbarium collections at BRIT and MO:

1. Corollas white, lobes and tube each 1.5–2.5 mm long; calyx lobes as long as or longer than corolla tube (Fig. 1) _____ **australis**
1. Corollas purple-violet or pink-rose, rarely white, tube exceeding length of calyx lobes.
   2. Stems 3–12 cm long; corollas purple-violet, occasionally pale purple to white, lobes 2.5–3.5 mm long, tube 3.5–4.5 mm long; calyx lobes about half as long as corolla tube; common _____ **crassifolia**
      3. Corollas purple-violet throughout _____ f. **crassifolia**
      3. Corolla lobes white to pale purple-violet, tube purple-violet to reddish _____ f. **albiflora**
   2. Stems 1–3 cm long, often clumped; corollas pink rose fading to light violet or nearly white, lobes 2.5–4.5 mm long, tube 5–7 mm long; calyx lobes 1.2–2.5 mm long; occasional _____ **rosea**

Hedyotis australis

Prior to 2005 the known continuous distribution of *H. australis* was limited to eastern Texas, Louisiana, Arkansas (excluding the northeast), southeastern Oklahoma (only McCurtain Co.), western and central Mississippi, and southwestern Tennessee (only Shelby Co.), in addition to outlying populations in cen



FIG. 1. *Hedyotis australis* W.H. Lewis & D.M. Moore common in lawn of cemetery, Natchitoches, Natchitoches Parish, Louisiana, *W.H. Lewis 15867* (MO). Arrow showing calyx lobes as long as corolla tube (sometimes longer). Bar equivalent to about 1 cm.

tral Alabama (Tuscaloosa Co.), and central and eastern Georgia (Bibb and Columbia Co.'s) (Chambers 1965, Lewis 1968, Terrell 1996). Its current distribution is now extended to include:

(1) southeastern Missouri.—northern Dunklin Co., N of Campbell, *15968* F, MO, UMO, US; northern Dunklin Co., NW of Campbell, *15969* MO; Butler Co., Poplar Bluff, *15970* MO, US. These are the first reports for Missouri. The Poplar Bluff collection at 36°76'N is the most northerly record of the species, although this distribution is similar to the new record at Paris, Tennessee (36°17'N). *Hedyotis australis* was found in Missouri's Bootheel region and adjacent Butler County in low foothills at the southeastern edge of Ozark Plateau where all three collections grew in grassy cemeteries and where herbicides were not used. None were found in nearby pastures or meadows or in lower-lying areas where cotton is now grown in large farms and where herbicides are widely used. The species was also absent from flood-plains and other riparian habitats to the east along the Mississippi River valley.

(2) northeastern Arkansas.—Greene Co., Paragould, *15921* MO, *15964* BRIT,

MO. As in Missouri *H. australis* was not found in the Mississippi River valley, but only along a low ridge just west of the Missouri Bootheel among grass in a hilly cemetery. This is its most northeasterly location in Arkansas which parallels its northwestern distribution (Smith 1988).

(3) western panhandle of Florida.—Escambia Co., Hwy 4 at Sandy Hollow Rd, *15936* FSU, MO, USF. This new outlying record was found in a hilly region of extreme northwestern Florida growing with *H. crassifolia* in grass by a roadside corner. Both species were in flower 22 March, although flowering had just begun for *H. australis* (no mature capsules) compared with numerous flowers and maturing capsules of *H. crassifolia*. Tetraploids like *H. australis* often have peak flowering later than their diploid relatives (as *H. crassifolia)* and this generalization applies here (Lewis 1980). *Hedyotis australis* was not seen elsewhere in Escambia County, adjacent Santa Rosa County, or nearby Mississippi and Alabama, although *H. crassifolia* was found with regularity.

(4) eastern Mississippi.—Hinds Co., Hwy 27 at Bear Creek Rd, *15930* BRIT, MO; Smith Co., Taylorsville, *15932* MISS, MO, US; Itawamba Co., Fulton, *15950* DAO, MO; Lee Co., Tupilo, *15951* MISS, MO; Union Co., New Albany, *15953* MO, US; Marshall Co., Holly Springs, *15954* MISS, MO. In Mississippi's southeastern area *H. australis* was only occasionally found along grassy roadside verges, but where found it was common while *H. crassifolia* was less so (Hinds, Smith Co.'s); in the northeast it was widespread in the more frequent upland areas (Itawamba Co., the most easterly Mississippi collection, Lee, Union, Marshall Co.'s) where *H. crassifolia* was also less common. Observation of fewer flowering plants suggests that flowering of *H. crassifolia* had peaked some time earlier rather than limited frequencies of plants.

(5) western Alabama.—Marion Co, Hamilton, *15949* BRIT, MO, US. Plants of this second collection known for Alabama were growing in abundance among other invaders in lawns. This new extension eastward in Alabama from those found in nearby northeastern Mississippi is about 80 miles northwest of the only other known Alabama collection at Tuscaloosa in Tuscaloosa Co. (Terrell 1996) where *H. australis* was re-collected (*15945* BRIT, MO, US) growing with *H. crassifolia* (*15946* BRIT, MO) and nearby (ca. 20 m) *H. rosea* (*15947* BRIT, MO, US), the most easterly record for this species.

(6) western Tennessee.—Tipton Co., Covington, *15926* MO; Fayette Co., Hwy 57 at Hwy 18, *15956* MO, US; Hardeman Co., near Bolivar City, *15957* MO, TENN; Gibson Co., Humboldt *15960* MO, TENN, Bradford *15961* MO, TENN; Henry Co., Paris, *15962* MO, TENN. To the one collection of *H. australis* previously reported in the extreme southwestern part of the state at Memphis (Shelby Co.) (Terrell 1996) are added numerous collections throughout western Tennessee as far east as 88° 15'W in Fayette, Gibson, Hardeman, Henry, and Tipton Counties found in lawns, hillsides, ruderal areas, and cemeteries. As in Missouri, the species was not found in the Mississippi River valley, but did occur with some frequency on

the eastern ridge and uplands eastward and as far north as near the Kentucky state line to Mississippi in the south. Although the species was not found in western Kentucky, it might occur there.

Hedyotis crassifolia

Many collections were made of *H. crassifolia* whose range, including *H. minima* (Beck) Torrey & Gray, extends from Maryland to Georgia west to Wisconsin and Iowa, and south from Kansas to central Texas along the Gulf Coast states to the panhandle of Florida (Terrell 1996). Often it occurs with *H. australis* and less commonly also with *H. rosea*, particularly in eastern Texas and Louisiana where all three species can be found in flower together. All are homostylous with different chromosome numbers; recently Church (2003) found *H. crassifolia* with cleistogamous flowers among greenhouse-grown plants. In-breeding is clearly predominant and no hybrids between the three species have been found. Thus, I was surprised to observe foraging in a population of *H. crassifolia* a bee, *Agapostemon virescens* (Halictidae), extending its proboscis into the corolla tube while wings beat and rapidly flying from one flower to another after a few seconds stay. It visited about 30 flowers (occasionally returning to the same one) of 12 or so plants during 3–4 minutes and then flew off. This occurred near the Appalachian ridge in Alabama, Clay Co., at the Baptist Church cemetery adjacent Highway 49, 23 March. No other species of *Hedyotis* was found in the vicinity; in fact few species were in flower. How common such visits might be in the early spring (few pollinators seen) is unknown, but that it was observed even once suggests a means of at least limited out-crossing for this homostylous species. One could venture that its distributional success covering a wide range of habitats compared to other related winter annuals might be due to the success of even secondary out-crossing in combination with in-breeding via homostyly and possibly cleistogamy.

Hedyotis rosea

In representative specimens for *H. rosea* Terrell (1996) includes a collection from Missouri in Dunklin Co., near Campbell, 5 April 1931, collected by *A.L. Grant s.n.* (MO). Recently George Yatskievych located a second sheet collected by *Julian Steyermark 406* (MO) on the same day, both undoubtedly made during the same collecting trip. Steyermark's label locality is more precise at "ca. 5 miles northwest of Campbell" in open flat ground surrounded by *Quercus phellos* woods. This is the same area of northern Dunklin Co. where new records of *H. australis* were found only in "protected" (from herbicides) cemeteries on 28 March 2005. Searches around Steyermark's locality, in much of the northern part of the county, and in neighboring counties proved fruitless. I suggest that this single outlying population collected in 1931 is extinct and that *H. rosea* is now extirpated from the Missouri flora. No collection has been found in neighbor-

ing Arkansas or Tennessee and the nearest *H. rosea* in central Arkansas (Terrell 1996) is about 175 miles southwest of the original Missouri find. Indeed the loss of habitat and heavy use of herbicides for many years in the Bootheel counties may have contributed to the loss of *H. rosea* and perhaps other species whose ranges once extended to this region.

ACKNOWLEDGMENTS

I thank Memory Elvin-Lewis, Washington University, who assisted me in the field during both 2005 collecting trips, Richard Clinebell, entomologist with the Missouri Botanical Garden, who determined the bee discussed under *Hedyotis crassifolia*, and N. Rogerio Castro for translating the Abstract into Spanish. I also acknowledge the use of important collections of *Hedyotis* at BRIT and MO.

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Book Reviews

Toshio Yoshida. 2005. **Himalayan Plants Illustrated *Himaraya shokubutsu daizukan*.** (ISBN 4-635-58031-8, pbk.). YAMA-KEI Publishers, Co., Ltd., 1-9-13 Akasaka, Minato-ku, Tokyo, JAPAN. Price: ¥13,000 (ca. $115), 800 pp., (773 pp. in color), 18.5 × 26 cm, in Japanese.

When I returned from field work in Asia in September of 2005, a book of beautiful photographs of Himalayan wildflowers was among the items in my mail. The book, *Himalayan Plants Illustrated*, is by Toshio Yoshida, one of the most talented, knowledgeable and intrepid photographers of alpine plants in eastern Asia. Mr. Yoshida has traveled widely to capture images of the characteristic plants of the Greater Himalayan region. Having also visited some of the areas where he has worked, I was amazed to see that he has managed to photograph so many of the species in one of the world's richest areas of plant diversity.

The photographs in the book are the fruits of the author's 20 years of field studies in the Himalayan region and in China, and from leading research tours throughout the area. The photos are richly supplemented by notes and descriptions compiled from the study of herbarium specimens and from the literature. The introductory material includes a fresh discussion of floristic zones and their delimitation in the Greater Himalaya, southern Xizang (Tibet) and the Hengduan Mountain region of China, based on the author's observations and interpretation.

The book contains 2,739 color photos covering 1,771 plant taxa, of which 1,586 are at species rank, 40 are subspecies, 61 are varieties, 2 are forms, and the remaining 82 are unidentified. The photos were taken in all parts of the Himalayan range; northern Pakistan, Kashmir, northwestern India, Nepal, Sikkim, Bhutan and Tibet, as discussed in more detail in the front pages of the book. The book may be compared with *Flowers of the Himalayas* by Oleg Polunin and Adam Stainton, published in 1984 by Oxford University Press. Polunin and Stainton's book covers 1495 plant taxa, with 694 color photos inserted in the last 128 pages, and 319 line drawings. Because of the politics of those days, the field sites covered by Polunin and Stainton are in about half the Himalayan range, excluding Bhutan, Tibet and most parts of Pakistan and Sikkim.

In Mr. Yoshida's book the photos and descriptions/discussions are on the same page, crossed referenced by number. Plants exhibiting a wide range of variation, a likely phenomenon in the Himalaya, are represented by two or more photos to give a sense of intraspecific variation. Below each photo is the plant name in Japanese, which is often the Japanese transliteration of the scientific name. Also provided, if there is sufficient space, are details of the photograph, including date, place, elevation, and information about the plants in the photograph. The letters A–Z3 preceding the place name below each photograph correspond to the 34 maps on the front pages. A brief guide to the letters is on the inside flap of the dust jacket and can be read without turning pages.

Each photograph is keyed to the corresponding text entry. The text entry gives the Japanese name, the scientific name and synonyms, if any, followed by distribution, flowering period, altitudinal distribution and details of the habitat and life form. The morphological description in the text matches the plants in the corresponding photo(s), since it is basically derived from author's field notes at the time the photo was taken and from dried specimens of the photographed plants if they were obtained. The descriptions are further enriched with information from the literature.

The 82 unidentified plants, which may represent new species or varieties, also have text with data about the photographed plants. They are provided with the name of the species that the author presumes to be its nearest relative.

Plant morphology, especially of species dwelling in the alpine zone, is strongly affected by the environment. With that thought in mind, the author has tried to include photos that show not only the plant, but its habit and its place within the habitat.

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The introductory material includes articles on the history of research on Himalayan plants written by Prof. Hideaki Ohba on pages 4–7, geobotany of the Himalaya on pages 8–11, and a map of the whole Himalaya. On pages 12–25 are 34 topographical maps. Botanical guides to the areas of the Himalaya are on pages 26–32. An analysis of the horizontal and altitudinal distribution patterns of the plants covered in the book is on pages 33–39 and adaptive strategies of alpine plants in the Himalaya are covered on pages 40–43. Himalayan plants in the Hengduan mountains of southwest China are discussed on pages 44–45.

Although the book is in Japanese, the high quality and detail in the photos make the diversity of the flora and vegetation in this unique and highly diverse area easy to comprehend. The number of individual taxa included for each genus provides a good sense of the range of diversity within large genera. Some examples: *Arisaema*, 17; *Astragalus*, 24; *Gentiana*, 33; *Impatiens*, 22; *Leontopodium*, 10; *Meconopsis*, 21; *Pedicularis*, 66; *Rhododendron*, 58; *Saxifraga*, 66; *Saussurea*, 40.

The book is beautifully bound on high quality paper and one of the nice features is that the pages lie flat when the book is opened at any page. Rumor has it that an English language edition is being considered.—*David E. Boufford, Harvard University Herbaria, 22 Divinity Avenue, Cambridge, MA 02138-2020, U.S.A., david_boufford@harvard.edu.*

Two British Orchid Books

ANNE and SIMON HARRAP. 2005. **Orchids of Britain and Ireland: A field and site guide.** (ISBN 0-7136-6956-X, pbk., durable field guide binding). A & C Black, 38 Soho Square, London, W1D 3HB, U.K. (**Orders:** +44 (0)20 7758 0200 customerservices@acblack.com; http://www.acblack.com/search.asp). £29.99 ($51.95 US), 480 pp, 360 color plates, numerous watercolors, line art, 49 maps, glossary, bibliography, index, 21.6 × 13.8 cm.

MICHAEL FOLEY and SIDNEY CLARKE. 2005. **Orchids of the British Isles.** (ISBN 0-9541916-1-7, hbk.). Griffin Press Publishing Limited, 35 Wessex Way, Cox Green, Maidenhead, SL6 3BP, UK (**Orders:** http://www.griffinpress.co.uk/orchids.htm). £45 ($78 US), 390 pp., extensively illustrated with color photographs; 50 maps, glossary, bibliography, index, 27.6 × 20.5 cm.

It is not often a reviewer has the opportunity to review two publications that cover the same subject and are published at the same time. This is the situation with both books on the orchids of the British Isles. Each book covers the ± 60 species known from the British Isles. Both books are packed with full-color photographs, maps, technical details, and similar information. Yet they are as different from each other as apples and oranges. While Foley and Clarke's large format book (published in association the Royal Botanic Garden, Edinburgh), contains the more technical information, the Harraps' work is designed as a field guide—and that it very much is. As a field guide the binding is a durable Flexibind type that is sown and opens flat at any given point. To call it a paper binding is an injustice. The photographs in *Orchids of Britain and Ireland* are meticulous and sharp in every detail. Although both books use the maps from *New Atlas of the British and Irish Flora* those reproduced in the Harraps' book are much easier to read owing to the fact that the distributional dots representing county records for specific time segments are in red, black, and green as opposed to those in Foley and Clark that are in graduated shades from black to grey to red to pale pink. The wealth of information that appears in both books is very complete and covers every possible aspect of the orchids including their taxonomy, with extensive notes on more than 50 subspecies, varieties, and forms; distributional information; ecology, and status. Synonyms are included, although in a slightly different format in each book. In *Orchids of Britain and Ireland* the Harraps go even further and detail the

history of the known populations and their current status. Both books treat the genera *Dactylorhiza* and *Epipactis* in great detail and make every effort to sort out the species, subspecies, and varieties—no simple task! It is not surprising that the bibliography and glossary are similar in each work.

Given that both books cover much of the same information what does one book have that the other does not?

Foley and Clarke @ £45
covers 55 species
more extensive historical information
superior chapter on orchid taxonomy
checklist of species
authors names with the species
photographic hints
keys to the genera and species of selected genera
chapters by guest authors on cultivation and conservation

Harrap @ £29.99
covers 56 species
extensive specific information for seeking the orchids (44 page site guide to 330+ places to see orchids)
easier to read distribution maps
chart for each species showing decline over the years
convenient field guide format
growth pattern graphics of several genera
comparative plate of the bee orchids, *Ophrys*, of Europe

Both books use the term variety is the sense of forma—color and growth forms and both are guilty of the misuse of the term albino. A true albino plant has no coloring other than white-stems, leaves, and flowers. What is usually meant is white flowered form often with the name *albiflora*. Although it is the only publication of the two with keys for identification, Foley and Clarke is by no means a field guide and the size limits its use as such. Having a copy of both books would be ideal. Use the Harraps in the field and then when returning home consult Foley and Clarke for confirming or additional information. The photographs in both books are excellent, but in Foley and Clarke many of the full-page images have blurred. I feel certain the original images were sharp but they were enlarged just a bit beyond their limits. The only noticeable errors I found in Foley and Clarke. The first, under *Spiranthes romanzoffiana* was simply information taken from an old source: that of *Spiranthes* {x}*steigeri* being a hybrid between *S. romanzoffiana* and *S. cernua*. It is not been viewed as such for over 25 years. *Spiranthes* {x}*steigeri* is a synonym for *S. ochroleuca*. Information under *Pseudorchis albida* stating that it occurs in North America from the east to Alaska is incorrect. The species, as *P. straminea*, is restricted to northwestern Newfoundland and a single site in western Quebec on the shore of Hudson's Bay. Both facts could have been easily found in *Flora of North America*.

Biographical information is given for both Foley and Clarke and their guest authors but none for the Harraps. It would have been nice to know a bit about them and their other work. All four primary authors should be congratulated on their work as these two books are a major contribution to the 21st Century's knowledge of wild orchid in the British Isles and are heartily recommended for both the novice and professional alike. If you are visiting the British Isles for an orchid hunting expedition the Anne and Simon Harraps' field guide will be especially useful.—*Paul Martin Brown, author, Wild Orchids of Florida, The Wild Orchids of North America, Wild Orchids of the Southeastern United States, 10896 SW 90th Terrace, Ocala, FL 34481, U.S.A., naorchid@aol.com.*

Orchids of Mexico

E. Hágsater, M.Á. Soto Arenas, G.A. Salazar Chávez, R. Jiménez Machorro, M.A. López Rosas, and R.L. Dressler. 2005. **Orchids of Mexico.** (ISBN 9-6878-8908-X, hbk.). Published by Instituto Chinoin, A.C., Mexico City. Spanish and English versions available. (**Orders:** redactamex@yahoo.com.mx; Redacta, S.A. de

C.V., Avenida 10 de Mayo # 249, Col. San Pedro de los Pinos, C.P. 03800 Mexico, D.F. MEXICO). $100.00, plus shipping, 304 pp., 650 color photographs, 13.25" × 10" (33.5 × 25.5 cm).

Initial disappointment may often give way to surprised delight. Such is the case of *Orchids of Mexico*. Given the publication and research history of the estimable authors I had expected a detail taxonomic treatment of the orchids of Mexico. Imagine my surprise when a large format-33.5 × 25.5 cm-'coffee table' book arrived! This sumptuously illustrated volume is much more orchids 'in Mexico' than 'of Mexico' and wastes no time in luring the reader to that country. I soon discovered that the taxonomic treatment I was so looking forward to is forthcoming on a searchable CD that will cover the 164 genera and 1200+ species with over 1500 color photographs, a checklist, and cross-referenced synonymy. The current publication mentions 162 of those genera and 450 of the species.

But back to the volume at hand; sitting before me is one of the lushest books on orchids I have ever seen. Apart from the text, which we will get to later, it is lavishly illustrated with the highest quality photographs and color reproduction I have seen in many years and the printing on heavy stock only adds to the quality of the book. The authors have provided us with not just an overview of the orchids that grow within Mexico, but with details of the several climatic and geological regions of the country shown at first in a two-page layout of a satellite image of Mexico. After relating the history of orchids, and orchid research in Mexico, with many reproductions of plates from well-known historic volumes, it concludes with the ethobotanical history featuring *Vanilla planifolia*. A brief chapter on orchid biology is amply illustrated with photographs of plants from flower to fruit to flower with the many stages in between.

Now to our adventure searching the wilds of Mexico. As we visit the eight various habitats the narrative highlights the many species of orchids that are present and and numerous vies of the habitats and illustrates them with color photographs. At this point few synonyms are given and occasionally the reader may be temporarily confused with some of the newer generic concepts for familiar species such as *Prosthechea citrina* for *Cattleya citrina and Tamayorkis* for a few species traditionally known as *Malaxis*. Many species found in Mexico are also found in the bordering regions of the southwestern United States, Texas, and Florida. It is always welcome to see photographs of these more southerly species that may be very rare in the United States. Because of the arrangement of chapters by habitat it requires consulting the index to find information on specific species. But that is not the apparent aim of this book. It is to immerse the reader in the diversity of the orchids of Mexico and the verdant and prolific varied habitats. A final chapter on Conservation efforts and successes is followed by detailed photo creits and an extensive bibliography.

Thanks to the team of authors and photographers the text is scientifically accurate and this reviewer did not note any incorrectly labeled or positioned graphics (a feat not many books of this scope can boast!). There few typographical errors with a missing letter i.e., seudobulb for pseudobulb, but nothing that could possibly distract from the intense text. Many photographers were credited in the book and the meticulous editing of these photographs has provided the finished book with a continuity not often seen in similar publications.

Is it expensive?—yes, at $100 -but worth every penny of the price. Keep in mind that two books were really written; one in Spanish and then one in English. Were *Orchids of Mexico* not sponsored by Chinoin I am sure it would have to sell for much more or not even have ever gone into production. If you have any interest in North American orchids, especially from the southern regions of that continent, do not pass up the opportunity to purchase this volume. And remember, that the interactive CD will soon be available to satisfy those of us who thrive on taxonomic treatments!.—*Paul Martin Brown, author, Wild Orchids of Florida, The Wild Orchids of North America, Wild Orchids of the Southeastern United States, 10896 SW 90th Terrace, Ocala, FL 34481, U.S.A., naorchid@aol.com.*

Orchids of Cuba

JUAN LLAMACHO (text) and JULIO A. LARRAMENDI (photographs). 2005. **The Orchids of Cuba—Las Orquideas de Cuba.** (Cloth. ISBN 84-933615-2-6, hbk.). Greta Editores, Plaza Mayor, 24 25340 VERDÚ, SPAIN. (**Orders:** +34 690 733 011, http://www.gretaeditores.com info@gretaeditores.com). 49.00 Euros [$58.19 2/13/06], 287 pp., Spanish-English in parallel columns, color photographs, interpretive graphics, table of species, and glossary, 9.6" × 7".

Following a recent trend for regional orchid books to be both scientifically accurate and written in such a manner that they are popular with the non-academic enthusiast, *The Orchids of Cuba* fulfills a geographic niche that has long been void. This work of two enthusiastic Cubans has produced not only the first full-color book on the orchids of the island archipelago but the first text in English (Spanish/English in parallel columns) that provides an alluring enticement to the island nation. Following an imprimatur by Carlyle A. Luer, M.D. and foreword by James Ackerman, Ph.D. the books starts with the basic biology of orchids and biogeography of Cuba and proceeds to merge the two, describing and illustrating the several regions of the nation. These regions and the orchids found within them are then treated in detail. Of the 305 species documented from Cuba at the writing of the book, more than 150 are treated in detail and, for the most part, have excellent color photographs. Both the author's and photographer's love of the pleurothallids (*Lepanthes* and related genera) is evident in the spectacular close-up photographs of many of these tiny species. Following the species treatments is a section on undescribed (those species that have not yet been identified and/or described to science) species, with the same high quality photographs. The book concludes with a table of all 305 species currently found in Cuba, their flowering times and biogeographic distribution, a brief bibliography, and an excellent glossary. What is unfortunately lacking is an index. Because of the arrangement of species it makes it difficult to find specific information quickly. A listing of synonyms for the species treated in full would also have been helpful. No keys to identification are given as this book is, hopefully, just the prelude to more publications covering all of the orchids of Cuba.

From the reviewer's standpoint *The Orchids of Cuba* has the same problem as most other works that treat orchids from the Caribbean and Central America/Mexico. When ranges are stated the occurrence of the species in the United States, usually Florida, is omitted. In part, this appears to be perpetuated error, as the same omissions occur in several works. Rather than relying on publications from a quarter century or more ago, simply consulting *Flora of North America* or *Wild Orchids of Florida* would have solved this problem. Those species included in this work and also documented from Florida include *Ionopsis utricularioides, Prosthechea boothiana, Sacoila lanceolata, Bulbophyllum pachyrachis, Epidendrum nocturnum, Liparis nervosa, Maxillaria crassifolia, Brassia caudata, Eulophia elata, Malaxis spicata, Habenaria distans, Phaius tankervilliae, Vanilla planifolia, Epidendrum radicans, Prescottia opligantha,* and *Pelexia adnata. Govenia utriculata* is erroneously attributed to Florida (*Govenia floridana* is the correct species). From a taxonomic standpoint little issue can be taken other than to note that the treatment and photographs of *Habenaria quinqueseta* are actually *H. macroceratitis* (syn. *H. quinqueseta* var. *macroceratitis*), and the curious treatment of *Sacoila lanceolata* and *Stenorrhynchos squamulosum*. The latter two both should be treated as *Sacoila* as the most obvious difference between *Sacoila* and *Stenorrhynchos* being the presence (in the former) or absence of a mentum (in the latter).

The English translation is excellent and very readable and the only error noted would be the incomplete name, or omission of a period after the abbreviation, in one of the authors' names: Gal for Galeotti. The book is printed on very high-quality, heavy paper and durably bound. It is to be highly recommended to all interested in the orchids of the Caribbean and south Florida as well.—*Paul Mar-*

tin Brown, author, Wild Orchids of Florida, The Wild Orchids of North America, Wild Orchids of the Southeastern United States, 10896 SW 90th Terrace, Ocala, FL 34481, U.S.A., naorchid@aol.com.

Splendor in the Hill Country Grass

BRIAN and SHIRLEY LOFLLIN. 2006. **Grasses of the Texas Hill Country.** 2006. (ISBN 1-58544-467-7, flexbound with flaps). Texas A&M University Press, 4354 TAMU, College Station, TX 77843-4354, U.S.A. (**Orders:** 979-458-3982, 979-847-8752 fax; http://www.tamu.edu/upress/). $23.00, 208 pp., 170 color photos, 7 lin art, 2 maps, black and white figures, glossary, bibliography, index, 5 3/4" × 8 1/2".

Grasses of the Texas Hill Country is a pictorial guide to grasses of the Hill Country region of Texas. Designed for the layperson, this book is full of crisp color photographs on a black background that clearly show the inflorescences (seed heads) of grasses common in the Hill Country as well as many other areas of Texas. Authors Brian and Shirley Loflin have created a guide that is easy to use with grasses grouped by similarities in inflorescence structure. The front and back book flaps serve as handy reference guides for inflorescence structure types and the icons used throughout the text.

The opening chapter of the book introduces readers to the Hill Country region and other vegetation regions of Texas. The introduction discusses the basic structures of grass and includes color images. Within the "how to use this book" section is a detailed explanation of the different inflorescence structure types used to organize the grasses in the book. This introductory section includes other items of interest such as a discussion on how plants are given scientific names, the meaning of those names, and a list of both the genus and common names of grasses included in this book.

There are seventy-seven grasses included in the book. Each grass has an associated profile that includes features of the species, plant uses, growing season information, and habitat information including soil, location and distribution. The features section of each profile includes important information such as typical height, description of grass inflorescence, some vegetation characteristics, whether the grass is cool or warm season, native or introduced and whether the grass is annual or perennial. Much of the feature information is included in a bar under the common name of the grass in a rather intuitive icon form. The economic usage sections describe a species' use as a forage grass, garden grass, landscape grass, or value to wildlife. Each grass profile has at least one large image of the inflorescence and many grasses have additional small inset photographs of growth habit in nature.

There are a few items that would have made this book more useful to both beginners and more experienced grass enthusiasts. There are fantastic photographs of the inflorescences included with each grass, but unfortunately the authors did not include photographs of the vegetative structures (ligule and auricle) needed to help identify grasses when the inflorescence is not available. However, the authors have included some vegetative structure information within the "features" of the plant description. It would have also been beneficial to have the growth habit photographs that accompany many of the plant descriptions for every grass included in the text. There were a couple of typos/mix-ups noticed; an example is the diagrammed photograph in Figure 5 where the auricle was incorrectly labeled as the ligule. Some other small typos were noticed. Despite these few items, there is no doubt that this is a very useable book for persons with an interest in learning grasses of the Hill Country area.

If you are a beginner to grass identification or are looking for a good color photograph guide to grasses for the Hill Country (and surrounding area) of Texas, *Grasses of the Texas Hill Country* by Brian and Shirley Loflin would be a terrific book to start with. The glossary, writing style and icon quick guide add to making this pictorial book an easy to reference and use. This book is easily recommended for use by young adults and general grass or plant identification enthusiasts.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

FREDERICK CAMPBELL and RICHARD DUBE. 1997. **Landscaping Makes Cents. (Paperback Edition).** (ISBN 0-88266-948-6.). Storey Publishing, 210 MASS MoCA Way, North Adams, MA, 01247. U.S.A. (**Orders:** # 66948, 1-800-441-5700, www.storey.com). $16.95, 170 pp., color and b/w figures, appendices, glossary, further reading guide, index, 8 1/2" × 11".

If you want to improve the look of your homes' landscape and increase its' resale value at the same time, be sure to pick up a copy of *Landscaping Makes Cents* by Campbell and Dube. The book is geared towards the individual who is either trying to improve their landscape by themselves or with the help of an outside contractor. The book is divided into three main sections, the first of which is a discussion of how landscaping can add or detract value from a home. The second section is how to plan for hardscape elements and plants as well as on thoughts on formulating a budget. The final section contains all the info you need to know when hiring an outside contractor.

The first section is subdivided into four chapters that can help readers recognize which elements of landscaping add the most value to their property; these chapters include several tip boxes and special considerations for improving aesthetics. Some of the more specific topics include how to determine the values of trees, plant location, removal, addition, environmental value, historic value and aesthetic value. The final chapter of the first section specifically addresses landscape considerations when buying, building and selling a home.

The second section of the book addresses considerations on planning a budget and a landscape. This robust section contains five chapters; among the issues covered are expected expenditures, landscaping considerations for buildings with various periods of time until potential resale, and finally the idea of financing help. Readers will need to investigate into budgets for their own situations, as the information included in Chapter five on budgeting is very generalized. Chapter six of this section includes discussion as well as multiple assessment tools to help readers think through and design their landscape. For example, one of the first tools encountered in this chapter is "What do you want in your landscape?" with seventy-plus landscape options you may want, including patios, storage sheds, small fruit trees, hot tubs, benches, gazebos, doghouses and flower bed types. The authors include a short discussion of aesthetic landscape design possibilities for readers to consider and an outline for plotting the actual design. Chapter seven discusses investing in hardscape elements with inclusion of wall types, fences, patios, walkways, arbors, drip edges lighting and others. Once again, the authors include a number of helpful tip and consideration boxes. Chapter eight provides the reader ideas for plantings in their landscape. There are discussions of different plant types, growth forms and some helpful hints and techniques for planting plants. One would need to do further research into the plants that would perform well in their particular areas (the authors have provided a USDA zone hardiness map in an appendix). The final chapter of this section discusses investing in a sustainable landscape. Readers are provided with many options and ideas for planting a sustainable garden including an excellent assessment tool for performing a self-environmental audit of ones' own property.

The final section of the book contains three chapters, which cover all aspects of hiring a professional landscape contractor. For those readers interested in hiring such a person, these chapters will be especially helpful for you. This section's first chapter discusses how to hire a contractor beginning with the titles, definition and services offered by various landscape professionals; it includes things to ask about prior to hiring the person. The second chapter of this section focuses on negotiating contracts. The final chapter is a very in-depth chapter on what questions to ask of contractor during the planning stages and how to address specific concerns. There is also an included appendix on how to evaluate the aesthetic value of ones' landscape.

Landscaping Makes Cents by Frederick Campbell and Richard Dube is easy to read and includes helpful tips, guidance and many topics for consideration in planning and designing a home landscape. *Landscaping Makes Cents* is recommended as a fantastic resource for readers who have an in-

terest in, either personally or through a landscape contractor, designing their home's landscape to improve both its financial and aesthetic value. –*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A*

ROBERT H. MOHLENBROCK. 2006. **Aquatic and Standing Water Plants of the Central Midwest: Filicineae, Gymnospermae and Other Monocots, Excluding Cyperaceae.** (ISBN 0-8093-2670-1, hbk.). Southern Illinois University Press, Carbondale, IL, U.S.A. (**Orders:** 618-453-6633, http://www.siu.edu/~siupress). $65.00, 400 pages, b&w line drawings, glossary and indexes to the common names and genus and species, 6" × 9".

Aquatic and Standing Water Plants of the Central Midwest: Filicineae, Gymnospermae and other monocots, excluding Cyperaceae by Mohlenbrock is a flora, which consists of the ferns, conifers, and other monocots, excluding the sedges portion of the larger *Aquatic and Standing Water Plants of the Central Midwest* series. The Cyperaceae family is included in another book by the same author within the same series title. The book's Central Midwest range includes: Ohio, Indiana, Kentucky, Illinois, Iowa, Missouri, Nebraska, and Kansas

The flora includes information on 221 species, including members of the genera *Azolla, Woodwardia, Equisetum, Isoetes, Lycopodiella, Osmunda, Acorus, Sagittaria, Elodea, Iris, Juncus, Lemna, Najas, Platanthera, Spiranthes, Calamagrostis, Echinochloa, Glyceria, Leersia, Zizania, Heteranthera, Potamogeton, Sparganium, Typha, Xyris*, and others. There is no overall key to determine family, but the individual families have keys to determine genus, as well as within genus keys to determine species. Each species is presented in the book by black and white drawings, which provides images including: plant habit, leaves, inflorescence, achene, fruit, and/or sheath/ligules for many grasses, as well as an accompanying detailed description.

The description for each species contains a great deal of information, including the current accepted specific epithet, synonyms, as well as the authority and references for publications on each specific epithet. Each species' description includes plant habit information, descriptions and measurements of leaves and flowers (when applicable), root types, inflorescence, notable colors and, where applicable, details on parts unique to the family or genus, such as root collar information in Poaceae. The description includes habitat information, with a listing of which states the species have wetland designations (i.e., FACW) within the U.S. Fish and Wildlife Wetlands Inventory. The author has also included handy quick field traits within the plant description to help determine that species from similar looking others.

Aquatic and Standing Water Plants of the Central Midwest: Filicineae, Gymnospermae and other monocots, excluding Cyperaceae by Mohlenbrock would be a nice addition to the library of any person who works with aquatic plants, right alongside Mohlenbrock's book on Cyperaceae within the same series. Although this series focuses on the Midwest, a number of the species included in this flora are found in various regions of North America. The black and white drawings are crisp, easy to read images that show major identification traits for the species. Some familiarity with family traits will be necessary to know which family key to use to identify a plant. The keys are straightforward, but the flora does contain a glossary for any unfamiliar terms, and is user friendly. The description for each species is thorough, which can help you conclude that you have determined the correct species or not; and includes very helpful "in the field" identification hints. If you need to identify monocots and ferns in aquatic regions, be sure to pick up this helpful book. —*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A*

French/English Review

DOV F. SAX, JOHN J. STACHOWICZ, and STEVEN D. GAINES (eds.). 2005. **Les invasions d'espèces: Considérées dans le cadre de l'écologie, de l'évolution et de la Biogéographie.** Sinauer Associates, 23 Plumtree Rd, Sunderland, MA 01375-0407, U.S.A. (**Orders:** 413-549-1118 fax; orders@sinauer.com; www.sinauer.com). $51.95, 495 pp., b&w figures and tables, 7"× 9 1/4".

French.—Ce livre constitue une vue d'ensemble de nombreuses recherches ayant été menées sur les espèces invasives selon trois perspectives, écologique, biogéographique ou se rapportant à l'évolution biologique de ces espèces.

Dix-sept chapitres ont leurs propos illustrés grâce à des exemples tirés de publications soigneusement sélectionnées parmi des études concernant aussi bien le milieu aquatique, aérien que terrestre.

Les grands noms de la recherche se sont rassemblés pour mettre leur savoir en commun. La contribution de 45 scientifiques a permis de prendre en considération un large éventail de sujets allant de l'étude des communautés microbiennes, aux populations aviaires, en passant par le rôle des maladies infectieuses sur les communautés naturelles par exemple.

D'après les auteurs, ce livre peut-être lu dans sa globalité afin de connaître les tenants et aboutissants de nombreuses études antérieures, mais peut également être abordé par chapitre individuel selon les préoccupations de chacun.

Le lecteur peut comprendre comment l'étude des espèces invasives est devenue une discipline scientifique phare depuis les dernières décennies. Par exemple, l'étude des espèces invasives permet d'appréhender la façon dont un écosystème fonctionne « les invasions permettent d'observer les processus en temps réel, plutôt que de déduire les processus ayant eu lieu dans le passé seulement grâce aux modèles qu'ils ont pu engendré ».

Ce livre est le dernier ouvrage sorti et constitue le premier de référence pour toute personne voulant orienter ses recherches vers les théories les plus récentes et vers les méthodologies dédiées à l'étude des invasions d'espèces.

English.—This book is an overview of previous research as well as current investigations about species invasions. The study of non native species and their invasions can provide insights into ecology, evolution, and biogeography.

There are seventeen chapters that cover everything from aquatic to aerial and terrestrial invasions; each chapter ends with its own set of supporting references. Leading researchers were brought together to review the field of invasion biology. The contribution of 45 scientists has provided the editors with a diverse array of invasion examples such as microbial communities, avian populations on islands, to the role of the infectious diseases on natural communities. The editors note, "Individually, we believe that each of these chapters has something significant to offer. Collectively, we hope that this book has much to offer to both invasion biology and to our fundamental understanding of ecology, evolution, and biogeography."

The reader will quickly gain an understanding of why the study of invasive species has become an important scientific discipline in the last few decades. For instance, the study of invasive species helps to better understand the function of an ecosystem. "Looking closely at invasions allow us to observe processes in real time, rather than having to infer the operation of processes that occurred in the past solely from the patterns they generated."

This is the most recent book on species invasions and I recommend it to anyone interested in the biology of invasive species. It is a source of up-to-date information on current theories and methodologies and will be useful to researchers and graduate students working in this discipline.—*Virginie*

H. Raquet, Graduate Student, Botany Curatorial Assistant, E.L. Reed Herbarium Department of Biological Sciences Texas Tech University Flint & Main Avenues Lubbock, TX 79410-3131, U.S.A., virginie.raquet@ttu.edu

ANNA PAVORD. **2005. The Naming of Names.** (ISBN 1-59691-071-2; hbk.). Bloomsbury Publishing, 175 Fifth Ave., New York, NY 10010, U.S.A. (**Orders:** http://www.bloomsbury.com/). $45.00, 384 pp., illustrated, 8" × 9 5/8".

The natural world presents innumerable objects which humans have needed to categorize and name; animals, germs, stars, storms, rocks, and other huge kingdoms have eventually been broken down into types and grouped so that we could begin to understand them. *The Naming of Names* traces the search for order in the natural world. Such a process has taken many centuries, and we have gotten better at it with a scientific understanding of the world, but the impulse has been there for as long as we have been thinking about the things around us. Pavord, author of the *The Tulip* (2001), *Flower Power: the Meaning of Flowers in Art* (2003), and an expert gardener, details the history of plant taxonomy from the ancient Greeks to 17th-century British botanist John Ray. She reveals the history of plant classification and shows how the process was affected by intellectual, political and cultural thinking. The journey, traced here in detail for the first time, involves the culture of Islam, the first expeditions to the Indies and the first settlers in the New World.

In Athens, Aristotle's pupil Theophrastus was the first man ever to write a book about plants. How can we name, sort, and order them? He asked. The debate continues still, two thousand years later. *The Naming of Names* gives a compelling insight into a world full of intrigue and intensely competitive egos. She has gone back to the ancient Greeks, and shown how thinkers through the medieval ages and Renaissance tried to get a grasp on the disorderly plant kingdom, with eventual success even before the taxo nomic standards laid down by Linnaeus which we still follow. It is the pre Linnaean efforts that Pavord has chronicled. There is also a history of plant illustration within these pages. The eventual woodcuts did not have to be crude, with many reproduced here showing swirling masses of plants or delicate leaves in fine detail. The final engravings that become included in plant books could show enough useful detail to be excellent field guides, although for centuries authors relied on previous works of folklore.

Along with Theophrastus, Pavord's highest praise goes to Englishman John Ray, who in 1696 coined the term "botany." He provided six rules by which to categorize plants, not only the ones familiar to him in England, but the spectacular finds being brought from distant lands. Others had previously insisted on classifying plants by use, which was entirely artificial, or more helpfully by leaf or seed form, but it was Ray who put botany on its first real foundation by noting the distinction of seeds that sprout with one leaf or two (we still classify monocotyledon and dicotyledon). He knew he was part of an ongoing process, predicting that future botanists would look back and "our proudest discoveries will seem slight, obvious, almost worthless." He might have been right, but seen as a tribute to their efforts, *The Naming of Names* shows how these discoveries, achieved over the centuries by curious, devoted, and fallible plantsmen, have brought us to our current understandings. Pavord's book essentially ends with Ray, barely mentioning the recent advances that have been made with DNA testing; such tests have confirmed much of what was eventually realized as the evolutionary tree, but have upset other parts as well. It has been a long botanical trip, and Pavord's deep scholarship and inclusion of gorgeous illustrations make the journey enormous fun. The book is lavishly illustrated, with a third of the pages being taken up with illustrations (most in color) nicely keyed to the text.

In the best sections, she slows down to draw detailed portraits of researchers and describe how each contributed to the slowly evolving (and, until the late 1600s, unnamed) science of botany. The story makes for wonderful scholarship and tributes to the plantsmen who eventually made the jungle comprehensible. It would be an excellent choice for public libraries with a readership interested in the history of botany.—*Gary Jennings, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*



ISSN 0036-1488

Volume 1 of the *Illustrated Flora of East Texas* is the first fully illustrated flora for East Texas, a species-rich area that contains roughly two thirds of all the plant species known for Texas. The book covers all the native and naturalized ferns and similar plants, gymnosperms, and monocotyledons (1,060 species) known to occur in East Texas.

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Illustrated Flora of East Texas

George Diggs, Barney Lipscomb,
Monique Reed, Robert J. O'Kennon

From Big "D" to the Big Thicket there is a land of beautiful prairies interwoven with groves of timber, stately pines, hardwoods, wisteria, honeysuckle, lilies, orchids, dogwoods, azaleas, and Texas Pride!

Austin College 1849
BRIT

This photographic guide to the Wild Flowers of Mombacho is color-coded and arranged by Family within the color sections. It covers flowering plants found on the whole of the Volcano; which includes both tropical cloud forest and dry, deciduous forest, at lower altitudes.

The book covers 200 plants, each of which has two or three photographs and a short description in both English and Spanish giving common name(s); a short description of the plant; height; flowering period; habitat and any known use of the plant. The vast majority of plants are likely to be found in similar habitats throughout tropical America and nearly one third are pan tropical, making this book of interest to a wide audience throughout the tropics.

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WILD FLOWERS OF MOMBACHO
NICARAGUA
FLORES SILVESTRES DEL MOMBACHO
BY HELEN PICKERING

BRIT
PRESS

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SERIES II

SOURCE OF CURRENT RESEARCH IN CLASSICAL AND MODERN SYSTEMATIC BOTANY

FOR READERS THROUGHOUT THE WORLD

VOLUME 22 NUMBER 2 23 NOVEMBER 2006

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A NEW NAME FOR *SIDA, CONTRIBUTIONS TO BOTANY* **(1962–2006)**

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Beginning in 2007, the journal *Sida, Contributions to Botany* will no longer be published by that name but instead will be called the *Journal of Botanical Research Institute of Texas (J. Bot. Res. Inst. Texas).* The new journal will have a new look but generally the same format, botanical focus, and editorial direction will remain.

Reason for change

The leadership of the Botanical Research Institute of Texas has decided the name "*Sida*" is offensive and has too much of a negative connotation because of its similarity to the word meaning AIDS in Spanish, French, Italian, and Portuguese. Perhaps the name change is a good thing but I am personally saddened to see Shinners' original and long-standing name displaced.

Brief History of *Sida*

1962—Lloyd H. Shinners, a member of the Southern Methodist University faculty and a prolific researcher and writer who wanted to edit his work and the work of others, published the first issues of *Sida*. He named the journal for a genus of yellow-flowered plants of the mallow family, distributed throughout the world and especially common in Texas. Shinners continued as editor and publisher until his death in 1971.
1971—Wm. F. Mahler, professor of botany at SMU, became editor and publisher.
1977—Barney Lipscomb became assistant editor to Wm. F. Mahler.
1982—Barney Lipscomb became editor; Wm. F. Mahler remained publisher.
1993—With Barney Lipscomb as editor, *Sida* became a publication of the BRIT Press.
2002—BRIT celebrated the 40th anniversary of *Sida, Contributions to Botany.*
2006—BRIT Press publishes last issue of *Sida, Contributions to Botany.*

Thank you

To all authors, we thank you for choosing *Sida, Contributions to Botany.* A big thank you to the hundreds and hundreds of individuals who generously supported *Sida* through their time and expertise in reviewing more than 1000 manuscripts published from 1962–2006.

Thanks to all authors, reviewers, subscribers (individuals, institutions, organizations), and readers for your continued interest and support. It is our plan to continue bringing you the best sources of current research in classical and modern systematics through the *Journal of Botanical Research Institute of Texas* with your continued support. I personally wish you the best in 2007 and beyond. Your comments are welcome.

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A NEW SPECIES OF WITCH-HAZEL (*HAMAMELIS*: HAMAMELIDACEAE) APPARENTLY ENDEMIC TO SOUTHERN MISSISSIPPI

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ABSTRACT

A new species of witch-hazel, **Hamamelis ovalis**, is described from Perry County in southern Mississippi, U.S.A. The red flower color, clonal habit, and late winter flowering suggest affinity with the Ozarkan endemic *H. vernalis*; however, the large leaves, unlike any specimens examined of American or Asian witch-hazels, readily differentiate *H. ovalis* from its congeners. The problematic *H. macrophylla* is discussed.

RESUMEN

Se describe una nueva especie de la avellana-bruja, **Hamamelis ovalis**, del condado de Perry, Mississippi del sur, los Estados Unidos. El color rojo de la flor, el hábito clónico, y la floración tardía en invierno sugieren afinidad con el Ozarkan endémico *H. vernalis*. Sin embargo, las hojas grandes, diferentes de cualquier espécimen examinado de avellanas-brujas americanas o asiáticas distinguen fácilmente *H. ovalis* de sus congéneres. Se discute el problemático *H. macrophylla*.

During surveys for proposed tracked vehicle maneuver areas at Camp Shelby Training Site in southern Mississippi, an unusual colony of witch-hazel (*Hamamelis*) was discovered in July 2004. Distinctive features initially observed were the large, abaxially pale whitish-green ovate leaves, densely pubescent cinnamon-brown twigs, and abundance of low clonal sprouts. The colony was periodically checked to see when anthesis would occur and if the petals would be yellow like all the known native *Hamamelis* plants in southern Mississippi. In early January 2005 the large tawny buds opened to expose brilliant red sepals and petals entirely maroon, scarlet, rose, or red with yellow tips. Subsequent surveys in the area revealed colonies with mixed flower colors as well as colonies with flowers entirely wine-red. Leaf and floral appearance as well as the clone-forming habit of the plants did not match anything known for *Hamamelis* from the Gulf Coast region.

Witch-hazel shrubs, with pale yellow petals less than 8 mm long and occasional plants with leaves less than 6 cm long are present at Camp Shelby. These yellow-flowered plants do not fit this writer's concept of *Hamamelis virginiana* L. var. *virginiana* of the Carolinas nor *Hamamelis virginiana* L. var. *henryae* Jenne ex C. Lane of northern Florida. However, for simplicity of discussion in this paper, they will be referred to as *H. virginiana*. Floristic treatments indicate a range for *H. virginiana* from Nova Scotia to Texas (Small 1933; Fernald 1950; Steyermark 1963; Radford *et al.* 1968; Godfrey 1988; Meyer 1997) and possibly Mexico (Jenne 1966; Lane 2005). In Mississippi these shrubs and small understory trees are frequent on acidic, sandy woodland slopes and bluffs, moist or dry, in full sun or shade. Flowering at Camp Shelby begins in November, peaks in December and tapers off in January. In addition to the native woodland *Hamamelis virginiana* in Mississippi, other witch-hazels are occasionally used as landscaping shrubs. These cultivars include

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the Ozarkan witch-hazel, *Hamamelis vernalis* Sargent, and less frequently the Oriental species, *Hamamelis mollis* Oliver, *Hamamelis japonica* Siebold and Zuccarini, and the hybrid *Hamamelis* × *intermedia* Rehder. Neither *H. vernalis*, nor the Asian plants are known to naturalize in Mississippi.

In March 2005 the dried collection of *Hamamelis* at the Missouri Botanical Garden Herbarium (MO) and late flowering specimens of *H. vernalis* Sargent on the Garden's grounds were examined. Although considerable variation in foliage was noted, nothing in the MO collection approximated the big-leaved, red-flowered plants found earlier at Camp Shelby, Mississippi. With no visible evidence that the Camp Shelby colony was located near a house site where cultivars might have been introduced, exotic witch-hazels were eliminated. Leaf size, pubescence, clonal habit, flower color, petal length, and phenology tended to rule out the common eastern witch-hazel, *H. virginiana*—highly variable as it is known to be.

Clonal habit and infusion of red in the petals suggested an affinity between the Camp Shelby plants and the variable *Hamamelis vernalis*, an Ozarkan endemic that grows 600 kilometers to the northwest of the Mississippi site. Rehder (1920, 1928) and Steyermark (1963) recognized forms of *H. vernalis* to account for the pure red flower color and tomentose leaves within certain colonies of *H. vernalis*. Jenne (1966) proposed that the variable-flowered, clonal plants of *H. vernalis* originated as putative hybrids between the eastern *H. virginiana* and an unknown parental type (possibly no longer extant). However, Bradford and Marsh (1977), after making comparative studies in Arkansas of *H. virginiana* and *H. vernalis*, were inclined to disagree with Jenne's interpretation of the hybrid origin of *H. vernalis*. Nevertheless, as Jenne (1966) hypothesized, a tentative Ozark relict "would be expected to be extreme in the following directions: short petal length, presence of red pigment in the petals and on the inner surface of the sepals, linear staminodia, less than 0.5 mm wide, the tips of which are not dilated, clonal habit of vegetative suckering, with 75 to 100 stems emerging from one root system." Looking at these features only, the Camp Shelby plants come uncannily close to Jenne's parental phenotype, but size and vestiture of leaves, branching pattern, habitat, and other characteristics are hard to reconcile the Camp Shelby shrub as a parent of *H. vernalis*.

On the other hand, with exception of variation in petal color, nothing about the Camp Shelby plants suggests a hybrid origin. In fact, other features such as larger leaf size, earlier flowering, musty floral fragrance, plant habit, and dry pineland habitat point toward an independently derived species. As documented below the Mississippi plants are sufficiently different from the Ozark plants to merit a taxonomic designation at specific rank. Therefore the following name and diagnosis are provided:

Hamamelis ovalis S.W. Leonard, sp. nov. (**Figs. 1–2**). TYPE: U.S.A. MISSISSIPPI: Perry Co.: shallow ravine in mixed pine-hardwoods near headwaters of Garraway Creek, Camp Shelby Training Area T-17, Compartment 96, DeSoto National Forest, T2N, R11W, Sec. 6, NE1/4, 7 Jul 2004, *S.W. Leonard 11073* (HOLOTYPE: MO; ISOTYPES: FSU, NCU, NY).

Frutex clonis, crescit ad 5 m. Differt a *Hamamelis virginiana* sepala eo quod scarlatinus vel rubropurpureus est, floris folia sunt coloris vinosi aut rosei; differt a *H. vernalis* eo quod folia magna ovata habet et pars obversa folii habet pilos stellatos albos.

Rhizomatous shrubs to 5 m tall with twigs densely stellate pubescent, brown to brownish-gray on older twigs; terminal buds russet. **Leaves** tardily deciduous, alternate, ovate 12–24 cm long, 5–17 cm wide, dark green and scurfy above, pale green with dense stellate tomentum below initially white and aging to golden tan, margins sinuate on distal half



FIG. 1. Flower (left) of *Hamamelis ovalis*, Perry Co., Mississippi taken on January 18, 2006. Leaves (right) of *Hamamelis ovalis* from type locality taken April 5, 2005. The ruler is 15 cm long. Note contrasting surfaces of leaves; pale green abaxial surface due to closely knit stellate pubescence that becomes golden brown late in the growing season.

and entire on proximal half; petioles 1.0–3.5 cm long; leaf bases oblique with longer lobe rounded to cordate, principal veins of leaves alternate, usually 11 (five on one side of midrib, six on the other); leaf apices acute to obtuse. Flowering late December to early February with peak around January 20; calyx of 4 ovate **sepals** 3–4 mm long, acute, densely tawny pubescent abaxially and glossy scarlet adaxially, spreading, slightly reflexed, and ultimately strongly reflexed with age, subtended by 2 or 3 densely tawny tomentose bractlets; **petals** liguliform, at first uncoiling 7 mm long and continuing to lengthen to 14 mm over a period of 3 weeks, circinnately coiled in bud and irregularly revolute when expanded, various shades of red (wine-red, scarlet, rose) or infrequently tipped with yellow; filaments purplish-red, gradually expanded toward apex and resembling gavels until anthers turn outward from the connective exposing sockets in the distal ends of the filaments; filaments alternating with staminodes; staminodes dilated distally and curved outward with the broader tips straddling the base of each petal, thus pushing the petal away from the stigmatic surface; ovary partly inferior, pubescent with mostly appressed hairs, fruits slightly compressed ca. 2 cm long calyx adhering to capsule except for recurved tips; seeds 2 per locule, glossy black, 7–10 mm long, slightly obovate with each face of attachment scar (2 mm wide and 3 mm long) about twice the width and length of attachment scars on seeds of *H. virginiana* from local populations (Fig. 1).

Ecology and phenology.—At the type locality, the plants occur in a shallow flat-bottom ravine and on adjacent low slopes. Soil at the site is loamy. The ravine drains into a headwater tributary of Garraway Creek that flows into the Leaf River between the City of Hattiesburg and the small municipality of New Augusta in Perry County, Mississippi. The location is in Compartment 96 of DeSoto National Forest, Training Area 17 of Camp Shelby Training Site, T2N, R11W, Section 6.

The *Hamamelis* occurs beneath a canopy of pine and mixed deciduous hardwoods. The main species of this vegetation are: *Pinus taeda, Pinus palustris, Carya tomentosa, Nyssa sylvatica, Quercus falcata, Magnolia macrophylla, Cornus florida, Sassafras albidum, Ilex vomitoria, Ilex opaca, Liquidambar styraciflua, Vaccinium arboreum, Vaccinium elliottii, Morella cerifera, Callicarpa americana, Tridens flavus* var. *chapmanii,*



FIG. 2. Clockwise from top left: *Hamamelis virginiana* (Forrest Co., MS), *Hamamelis ovalis* (Perry Co., MS), *Hamamelis vernalis* (Taney Co. MO), *Hamamelis virginiana* (Perry Co., MS). Each specimen is mounted on a standard herbarium sheet.

Chasmanthium sessiliflorum, Sorghastrum elliottii, Smilax pumila, Mitchella repens, Berchemia scandens, and *Vitis rotundifolia.*

Flowering of *Hamamelis ovalis* was observed in late December with the peak occurring around the first ten days of January in 2005. The 2006 peak (during an unusually warm January) was closer to January 20th. In addition to the taller plants developing flowers, clonal sprouts—some no more than 20 cm tall—also flower.

The following observations were made in 2006 on potted plants of *H. ovalis* and *H. vernalis*: flowering of *H. ovalis* begins (late December) as flowering of *H. virginiana* is ending; flowering of *H. vernalis* begins (mid-February) as flowering of *H. ovalis* is ending. Leaves of *H. ovalis* are 30–40 percent of mature size before the leaves of *H. vernalis* begin to emerge from the buds.

Habit and morphology.—Although *Hamamelis ovalis,* like *H. vernalis,* is a clonal shrub, the root sprouts are generally uniform in height on upper slopes where prescribed fire at 2–6 year intervals is a standard longleaf pine management procedure. These small shoots, typically 3–5 dm tall, extend outward as much as 6–8 meters from the central plant. However, the habit of the *H. ovalis* is markedly different from that of *H. vernalis.* Instead of forming a rounded bush of several sucker stems with major branches diverging in all directions from near the base of the plant as in *H. vernalis,* mature shrubs of *H. ovalis* have two growth forms—distichous branching on a geniculate central axis and a graceful arched branching on an erect straight stem. On the former, alternate branches diverge at approximately right angles in the same plane, gradually becoming longer as they progress up the main stem, thus giving the plants an espaliered look. Rhizomes of *H. ovalis* are 6–10 mm in diameter and are shallow, often just beneath the leaf duff. In contrast, rhizomes of *H. vernalis* are deep seated among overwash stones in flood zone sands. Specimens along the Caddo River in Clark County, Arkansas were tightly bound to the substrate and not easily extracted.

The type locality colony of *Hamamelis ovalis* comprises 92 stems greater than 1.5 m tall with the tallest being 3.8 m ($\bar{x}$2.3 m) and about 120 smaller sprouts. It is estimated these 200+ stems arise from the rhizomes of fewer than two dozen plants. Field work during 2005 in the headwaters of Garraway Creek revealed about two dozen smaller colonies of witch-hazel in drier habitats: upper slopes, crests of ridges, and 1–2 hectare level areas now covered with mixed longleaf and loblolly pine secondary growth forests.

Calyces are consistently deep reddish-maroon adaxially with conspicuous tawny hairs from the dense abaxial pubescence protruding along the lobe margins. Calyces of some plants become tinged with green toward the base of the lobes after the petals wither. Petals were predominantly wine-red, scarlet, and reddish-pink, with at least one plant having yellow petals with the basal half deep red. Petals persist for around three weeks before they begin to turn brown from the tips progressively toward the base. Floral fragrance of *H. ovalis* is at first faintly spicy or "fruity," thereafter degrades to a musty scent similar to that of decaying pears, and eventually to a disagreeable "wet dog" odor!

One of the distinctive features of *Hamamelis ovalis* is the abaxial appearance of mature leaves in the early part of the growing season. If viewed at an angle in direct sunlight, the developing leaves have a hoary white appearance above due to closely spaced stellate hairs. At the same time the lower surface is whitish (very pale green) from closely-knit stellate pubescence.

On plants of *Hamamelis ovalis,* even short sucker sprouts, two or three of the leaves

toward the stem tip will be greater than 20 cm in length. This dimension exceeds maxima for all witch-hazel taxa currently described. In autumn the leaves of *H. ovalis* turn yellow, then brown, and many continue to hang downward on the branches until mid-March.

An observation that may have some bearing on data collection from herbarium specimens is that witch-hazels respond vigorously after forest fires. At Camp Shelby Training Site, stems of *Hamamelis virginiana* in the first one or two growing seasons after fire have larger than normal leaves, usually 16–18 cm long. These post-fire leaves tend to have cordate rather than oblique leaf bases and lack conspicuous abaxial pubescence.

Hamamelis ovalis* vs. *H. vernalis

1. Leaves ovate, 12–24 ($\bar{x}$19.7) cm long, 5–17 cm wide, soft velvety green above for first half of growing season and then becoming darker green and scurfy above; pale green below with dense white tomentum in spring that gradually turns golden brown in autumn, margins slightly sinuate on distal half, base rounded, strongly cordate oblique, usually 11 major veins arising from midrib with 5 on one side and 6 on the other; suckers from base of main stem absent; plants strongly soboliferous with rhizome sprouts mostly less than 5 dm tall; flowering late December to early February, flowers faintly spicy becoming musty for the three-week duration of the petals _____ **H. ovalis**

1. Leaves mostly obovate, 7–13 ($\bar{x}$=8.7) cm long and 4–10 cm wide glabrous above or sparingly stellate pubescent becoming darker green and smooth above; glaucous beneath or rusty stellate pubescent along midrib and veins, margins sinuate apically, cuneate basally or infrequently weakly rounded and oblique, usually 9 or 10 major veins arising from midrib; plants suckering strongly from base and occasionally sending up rhizome sprouts that form dense thickets 2–3 meters tall; flowering late February throughout March, flowers sweetly aromatic _____ **H. vernalis**

Leaves of *Hamamelis ovalis* are more than twice as large as leaves of *H. vernalis*, and seldom if ever have an obovate shape. In contrast, foliage of *H. vernalis* observed along the Caddo River in Arkansas as well as leaves of cultivated plants of this species are consistently obovate, slightly glaucous, and with broad cuneate bases. Flowers of *Hamamelis ovalis* are similar in size and possibly as variable in color as *H. vernalis*, but lack the pronounced fragrance.

Hamamelis ovalis* vs. *H. virginiana

1. Large ovate leaves with pale densely stellate tomentum on abaxial surface; mostly 11 lateral veins per leaf; abundant short rhizome sprouts sometimes forming a groundcover; tawny pubescent twigs of current and previous season's growth; flower buds and terminal buds larger, scarlet adaxial surface of calyx; maroon, scarlet, or deep pink petals and larger; flowering principally in January in Mississippi; glossy black seeds with larger attachment scars _____ **H. ovalis**

1. Leaves 3.7–16.7 cm long and 2.5–13 cm wide (Meyer 1997); elliptic, obovate, nearly rounded; margins sinuate, base broadly cuneate, rounded, weakly to strongly oblique with one lobe rounded the other cuneate; surface dull green above, scabridulous or smooth, lower surface pale green, glabrous or pubescent or tomentum restricted to midrib and major veins; 9 or 10 lateral veins arising from midrib; plants suckering from base with only a few sprouts arising from rhizomes; flowers pale yellow, smaller (6–8 mm) than published dimensions [10–20 mm (see Meyer 1997)] for the species, opening in November to mid-December, seeds slightly smaller with smaller attachment scars _____ **H. virginiana**

Features that differentiate *Hamamelis ovalis* from the widespread eastern North American *H. virginiana* are the larger leaves with pale densely stellate tomentum on abaxial surface; tawny pubescent twigs, longer bud scales, scarlet adaxial surfaces of calyx, reddish petals instead of typical yellow, floral fragrance, and strong development of clonal sprouts. Flowering of *H. ovalis* begins (late December) as flowering of *H. virginiana* is ending.

Among the nearly two dozen discrete colonies of *Hamamelis ovalis* observed at Camp

Shelby, only one has been found that contains both *H. ovalis* and *H. virginiana* (small leaf form) and at this site there are only a few plants of the latter. In areas where *Hamamelis ovalis* occupies drier sites at the heads of drainages, *H. virginiana* tends to be a streamside plant.

Identity of *Hamamelis macrophylla*

Because the large leaf size of the new Mississippi witch-hazel is one of its most distinctive features, a logical name for the shrub would be *Hamamelis macrophylla*. This name was in fact used by John Lyon, a Scottish nurseryman working out of Philadelphia and making commercial collecting trips as far south as Georgia and Florida. Where Lyon found his new species is unknown. He offered it for sale in 1812 under the name *Hamamelis macrophyllus* sp. nova, but he did not publish a Latin diagnosis (Ewan and Ewan 1963). Pursh appropriated the name, provided a brief Latin diagnosis, and published the name in his *Flora americae septentrionalis* (Pursh 1814). Although Pursh said the type came from "river banks in the western part of Georgia," Ewan and Ewan (1963) pointed out in a footnote to the annotated Lyon journal that some of Pursh's locations were not "trustworthy." Loudon, a Lyon biographer writing in 1844, according to Ewan and Ewan (1963), said the witch-hazel was native to the "Katawba (sic) Mountains." This location would place the type locality in western North Carolina.

Regarding the Lyon/Pursh *Hamamelis macrophylla*, Pursh described only "large leaves punctated on their lower side, with rough tubercles and other marks...." Apparently he never saw flowers of *H. macrophylla* and if Lyon saw the plants in flower, he either withheld the information from Pursh or omitted it from his journal of 1799–1814. Pressed specimens were either lost or destroyed.

A clue regarding the provenance of *Hamamelis macrophylla* might be ascertained from associated flora. Having seen the magnificent *Magnolia macrophylla*, Lyon seemed to have become obsessed with it and is said to have collected more than 4,000 seedlings from a single location in North Carolina (South Carolina Association of Naturalists newsletter June 1996). It is possible that on one of his collecting trips to *Magnolia* colonies in western Georgia (or western North Carolina?) he collected a large-leaved *Hamamelis*. According to Lyon's notes of his Georgia travels, he was near the Ocmulgee River on June 23, 1803, the Flint River on July 17, 1803, and the Chattahoochee River on October 6, 1803. However, these dates appear to be too early if the witch-hazels were not advertised for sale until 1812. A more likely site and date of collection would be western North Carolina near the Catawba River in October 1809, when Lyon packed 3,600 seedlings of *Magnolia macrophylla* for shipment to Europe.

Magnolia macrophylla is a frequent associate of *Hamamelis ovalis* in the upper Garraway Creek watershed in Mississippi. If the Georgia or the Carolina plants bloomed in late winter or spring, were red-flowered and were clonal, then Pursh's *Hamamelis macrophylla* might be the same species as recognized here as newly described. If the Mississippi plants were a colony of a conjectured red-flowered *H. macrophylla*, such a disjunction would be about 425 kilometers from a theoretical site in Georgia or more than 1,100 km from a North Carolina location, based on the distribution of *Magnolia macrophylla* and assuming the magnolia's range has changed little since the early nineteenth century.

Treatments of the common eastern *Hamamelis virginiana* have included *Hamamelis macrophylla* Pursh as a synonym (*e.g.* Sargent 1922; Coker & Totten 1945). Unless, however, John Lyon's steps can be retraced to an extant colony of a big leaf witch-hazel, or

unless nursery stock from Lyon's 1812 sale has been propagated for almost two centuries in an English garden, the true identity of *H. macrophylla* may never be known.

ACKNOWLEDGMENTS

My thanks to Alan S. Weakley, NCU Herbarium Curator, for searching references tucked away in the University of North Carolina archives and to Mary Stevens of the Mississippi Museum of Natural Science for obtaining the paper by Bradford and Marsh. Lisa Yager, Camp Shelby Field Office Coordinator, arranged interlibrary loans of two crucial documents. Suggestions by reviewers, Guy Nesom, Bruce Sorrie, and Stephen Spongberg greatly improved the manuscript. I thank Fr. Peter Verhalen for corrections to the Latin diagnosis, the Mississippi Army National Guard for funding, and the US Forest Service, DeSoto Ranger District, that has final management responsibility for conservation of the species and its habitat.

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ERIOGONUM CALLISTUM (POLYGONACEAE), A NEW SPECIES FROM THE TEHACHAPI MOUNTAINS OF CALIFORNIA

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ABSTRACT

Eriogonum callistum, a new species of subg. *Eucycla* Nutt. from the Tehachapi Mountains of Kern Co., California, is the sole representative of **Sect. Lanocephala**, a new section allied to Sect. *Lachnogyna* Torr. & A. Gray, a taxon mainly of the Great Plains, but probably more closely related to Sect. *Latifolia* Benth. of the Pacific Coast. The new species differs in forming large, compact, roundish mounds of densely clothed caudex branches and rosettes of new leaves from which arise several upright scapose flowering stems terminated by a capitate inflorescence subtended by many bracts with many involucres containing numerous, hairy, bright white flowers on long, hairy pedicels, and glabrous, trigonous achenes.

RESUMEN

Eriogonum callistum, una nueva especie del subg. *Eucycla* Nutt. de las montañas Tehachapi de Kern Co., California, es el único representante de la **Sect. Lanocephala**, una sección nueva próxima a la Sect. *Lachnogyna* Torr. & A. Gray, un taxon de las Grandes Llanuras principalmente, pero probablemente más relacionado con la Sect. *Latifolia* Benth. de la costa pacífica. La nueva especie difiere por formar grandes masas compactas redondeadas de ramas hojosas y rosetas de hojas nuevas, de las que surgen hacia arriba varios tallos floridos escaposos que terminan en una inflorescencia capitada subtendida por muchas brácteas, con muchos involucros que contienen numerosas flores blanco brillante, sobre pedicelos largos y pelosos, y aquenios trígonos glabros.

The discovery of another undescribed member of *Eriogonum* Michx. (*Polygonaceae* Juss., subf. *Eriogonoideae* Arn.) from California is not, in itself, a surprise, but one so distinct as to represent a new section, and of such potential as a cultivated garden plant, is at least unusual.

Eriogonum Michx. Sect. **Lanocephala** Reveal, sect. nov. TYPE: *Eriogonum callistum* Reveal.

A *Eriogono* sectionibus singularis floribus et pedicellis pilosis.

Eriogonum callistum Reveal, sp. nov. (**Fig. 1**). TYPE: U.S.A. CALIFORNIA: Kern Co.: Tehachapi Mountains, 26 May 2006, *R.E. Preston 2400* (HOLOTYPE: UC; ISOTYPES: NY, RSA, US).

A *Eriogono lachnogyno* Torr. ex Benth. foliis latioribus et longioribus, involucris numerosis (10–35 nec 2–5), et floribus albis (nec flavis) et *E. latifolio* Sm. floribus pilosis differt.

Plants perennial forming densely white-tomentose, rounded, compact mounds, 3–10(–11) dm across and (0.5–)1–3.5 dm high, arising from a stout, woody taproot with numerous, spreading, tightly compact caudex branches covered with marcescent leaves ultimately terminated by a tight leafy rosette of numerous, newly-formed basal leaves; *leaves* fasciculate in terminal tufts, persistent, the petiole 1.5–5 cm long, grayish-white tomentose, the petiole-base narrowly triangular, glabrous, 0.5–3 cm long, 0.3–0.8 cm wide, becoming

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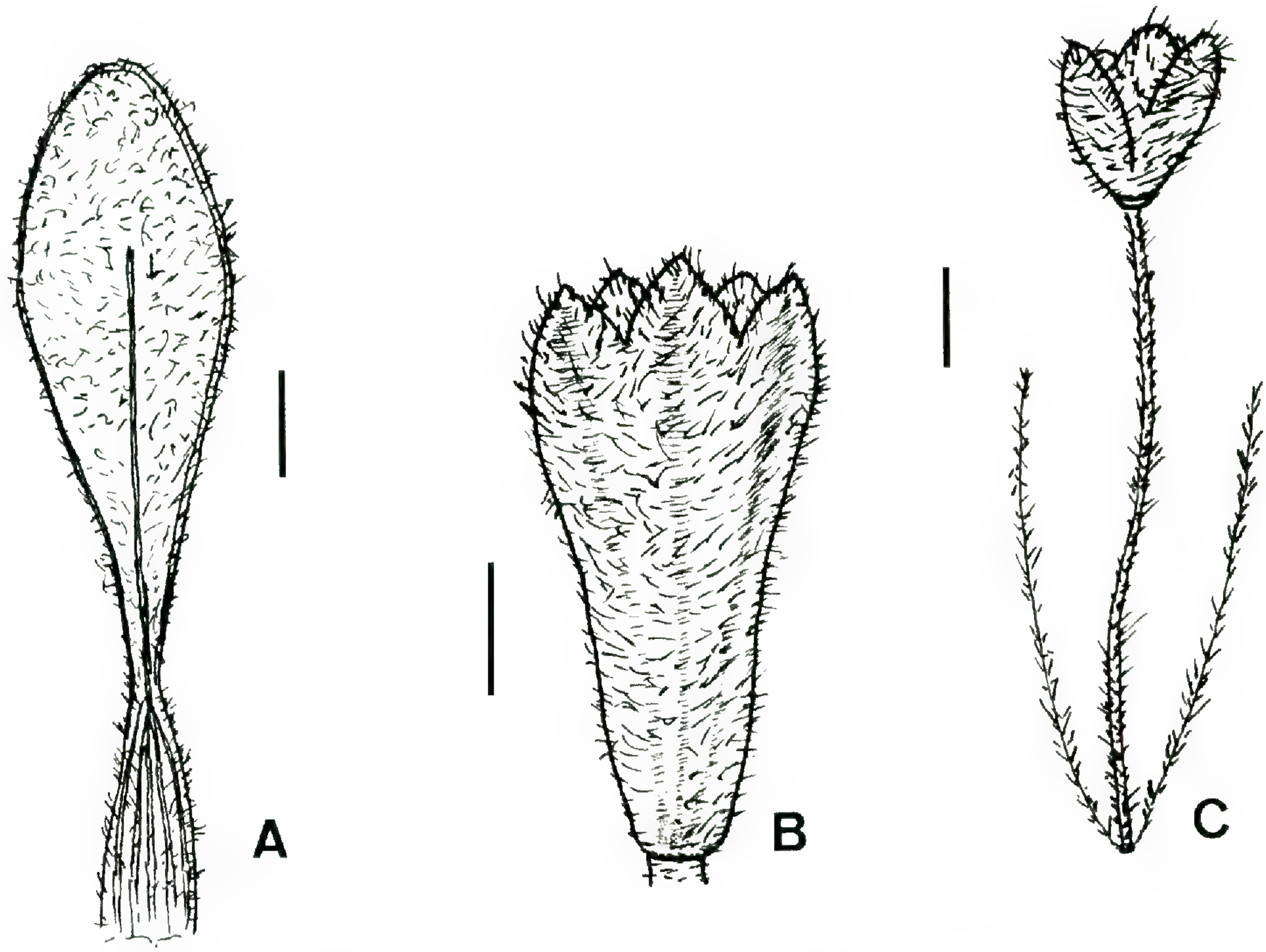


Fig. 1. Illustration (left to right) of a leaf, an involucre, and a flower with its pedicel and bractlets.

papery and reddish-brown with age, the blade elliptic, flattened or slightly folded longitudinally, (1–)2–5 cm long, 0.8–2 cm wide, silky grayish-white tomentose on both surfaces, the margins entire, flat; *flowering stem* scapose, arising centrally from rosette, erect or nearly so, slender, solid, not fistulose, (1.5–)2–4(–4.5) dm long, greenish to grayish, becoming reddish with age, thinly tomentose; *inflorescences* capitate, 2–4 cm across; *bracts* 8–16, subfoliaceous, linear to narrowly lanceolate, 4–12(–15) mm long, 1–3 mm wide, tomentose on both surfaces except glabrous basally on adaxial surface; *peduncles* absent; *involucres* 10–25(–35) per cluster, turbinate, (5–)6–8(–9) mm long, 2–4 mm wide, rigid, tomentose abaxially, glabrous adaxially, the teeth 5, erect, 2–3.5 mm long, acute apically; *flowers* bisexual, not attenuated basally, 2–5 mm long, the pedicels pilose, (5–)6–10(–12) mm long, the bractlets linear, 4–8(–10) mm long, pilose throughout, the perianth pinkish-white in bud, becoming bright white, densely white tomentose with long, soft hairs abaxially, glabrous adaxially except for glands along the rosy to yellowish-green midribs, the tepals connate 1/4–1/3 their length, essentially monomorphic, oblong to elliptic, the outer three slightly broader than the inner three; *stamens* exserted, 3–6 mm long, the filaments pilose proximally, the anthers oblong, pale yellow with a tinge of pink to light rose, 0.4–0.5 mm long; *achenes* trigonous, 3–4 mm long, glabrous.

Other specimens examined: **U.S.A. Kern Co.**: Tehachapi Mountains, 13 Jun 2006, *B.D. Schafer 214* (DAV, NY, RSA, UC, US); 25 Jul 2006, *J.L. Reveal et al. 8781* (NY, RSA, UC, US).

Eriogonum callistum (from *kalliston* Gr., most beautiful; **Figs. 2, 3**) represents a new section within subg. *Eucycla* Nutt. The Sect. *Lanocephala* (from *lenos* Gr., wooly hairs, and



FIG. 2. Habit of *Eriogonum callistum*.



FIG. 3. An inflorescence of *Eriogonum callistum* at anthesis.

kephale, head, as to the pilose flowers on hairy pedicels arranged in a capitate inflorescence) is similar to Sect. *Lachnogyna* Torr. & A. Gray, a taxon of two species encountered from eastern Arizona to western Texas northward onto the southern Great Plains to Colorado and Kansas. Although the type, *E. lachnogynum*, has hairy achenes, the other species, *E. havardii* S. Watson, has glabrous fruits. The soft, silky, grayish-white tomentum of the leaves of *E. callistum* is similar to that seen in both species, and while both members of Sect. *Lachnogyna* have yellow flowers, those of *E. callistum* are a bright white. The monospecific section is probably more closely allied to Sect. *Latifolia* Benth., and specifically the coastal element of the taxon, *E. latifolium* Sm. Both form rounded mounds of leaves and have numerous involucres in capitate heads. Still, *E. latifolium* is best characterized as a subshrub or shrub with long, aboveground, woody stems. *Eriogonum callistum* is an herbaceous perennial with short, stout, caudex branches buried in a mixture of soil and marcescent leaves. Nonetheless, Sect. *Lanocephala* is the only taxon in the genus with hairy pedicels. The flowers of *E. callistum* are individually small but numerous in numerous involucres that together form a capitate cluster atop long, slender scapes. The achene is trigonous, glabrous, and contains a curved embryo in abundant mealy endosperm; as such it is typical of most species of subg. *Eucycla*. Ongoing molecular studies should resolve an exact placement of Sect. *Lanocephala*.

At present, *Eriogonum callistum* is known only from a few scattered locations that altogether contain some 2000 individuals in a variety of age classes. The new species grows mainly in open places among manzanita on rock outcrops of pre-Cretaceous limestone (Jennings & Strand 1969), on open ridges within mixed chaparral. Associated species include *Adenostoma fasciculatum* Hook. & Arn., *Amelanchier utahensis* Koehne, *Arctostaphylos glauca* Lindl., *Arctostaphylos parryana* Lemmon, *Hesperoyucca whipplei* (Torr.) Trel., *Pinus monophylla* Torr. & Frém., *Ceanothus cuneatus* (Hook.) Nutt., *Quercus berberidifolia* Liebm., *Tauschia parishii* (J.M. Coult. & Rose) J.F. Macbr., *Castilleja martinii* Abrams, and *Corydanthus eremicus* (Coville & C. V. Morton) Munz.

In the key to *Eriogonum* in *Flora of North America* (Reveal 2005), the new wild buckwheat will key to subg. *Eucycla*, Key 1–California (p. 225) and will proceed to lead number 12 (p. 226). That may be modified as follows:

12. Perianth glabrous; s Sierra Nevada, Transverse Ranges, and desert ranges to the east from Mono County s to Los Angeles and San Bernardino counties _____ **73. Eriogonum kennedyi**

12. Perianth pubescent; Last Change Range, Inyo and Mono counties, or Tehachapi Mountains, Kern County.

12a. Achenes pubescent; pedicels glabrous; scapes up to 0.3 dm long; Last Change Range, Inyo and Mono counties _____ **68. Eriogonum shockleyi**

12a. Achenes glabrous; pedicels pilose; scapes 2–3.5 dm long; Tehachapi Mountains, Kern County _____ **92a. Eriogonum callistum**

The author has agreed not to publish at this time detailed information as to the exact location and distribution of *Eriogonum callistum*.

Eriogonum callistum should make an attractive addition to the rock garden flora. The large, roundish mats are composed of numerous tight rosettes of persistent leaves that remain attractive long after flowering. The fresh leaves, plus those of previous years that remain on the caudex branches, allow the mats to accumulate soil and plant debris and thus enlarge as roundish mounds with each growing season. The numerous, closely arranged caudex branches mean that the plants can be grown as tight, compact clusters along borders or in patterns. The plant's natural habitat suggests that it requires little

watering, prefers gravelly soil in open, sunny places, and should survive with little or no maintenance.

ACKNOWLEDGMENTS

I wish to thank Hazel Pollard for preparing the line drawing.

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Book Review

Guy Gusman and Lillian Gusman. 2006, **The Genus Arisaema, a Monograph for Botanists and Nature Lovers, Second Revised and Enlarged Edition**. (ISBN 3-906166-37-6. Publisher: ARG Gantner Verlag Kömmaditgellschaft FL 9491 Ruggell. Distributor: Koeltz Scientific Books, POB 1360, D-61453 Königstein/Germany. (**Orders:** Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A.; www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax). US$79.95 and C$109.95. 474 pp., 400 +color photographs, 29 figures, and 18 tables, 6 3/8" × 9 1/2".

This Second Edition includes more than ten new species described since the First Edition was published, many new photographs, geographical distribution of species by country, revised character tables for key species, recent developments in *Arisaema* taxonomy, types of accepted taxa and updated bibliographical references.

"The genus *Arisaema* consists of about 200 species, subspecies and varieties whose extraordinarily wide range extends from Central and East Africa towards Southeast Asia, via Yemen, Oman, Pakistan, Afghanistan, the whole Himalayan range, India, China, Korea, Japan and Siberia and eventually to North America. *Arisaema* is the third largest of the 105 genera that make up the *Araceae* (Mayo, Bogner & Boyce), 1997), a remarkable family of monocotyledons that contains some of the most extraordinary plants in the world." (pg. 12)

This, a second, revised and enlarged edition, is a comprehensive book on the genus, written by two collectors and growers, who are themselves scientists. Commonly called Cobra-Lilies, most do not resemble a snake and the genus is unrelated to lilies. The initial chapters include morphology, use in chemistry and medicine, occurrence in the wild and in cultivation, propagation and systematics. Most of the book is taken up in the description of species by each of the 15 sections, which includes photographs, drawings, tables, etc. Chapters on doubtful species, invalid names and then hybrids follows. The final three chapters include a glossary, bibliography, and an index to species names.

The book is a must have for botanists, horticulturalists, plant collectors, gardeners, growers, and anyone interested in the fascinating genus, *Arisaema*.—*David Leedy, Volunteer, Botanical Research Institute of Texas, Fort Worth, TX 76102-4060, U.S.A.*

SIX NEW COMBINATIONS IN *DODECATHEON* (PRIMULACEAE)

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ABSTRACT

Six new combinations are required in *Dodecatheon* L. for a forthcoming treatment of the genus in *Flora of North America north of Mexico*: **D. clevelandii** Greene var. **gracile** (Greene) Reveal, **D. clevelandii** var. **insulare** (H.J. Thomps.) Reveal, **D. clevelandii** var. **patulum** (Kuntze) Reveal, **D. pulchellum** var. **macrocarpum** (A. Gray) Reveal, **D. pulchellum** var. **shoshonense** (A. Nelson) Reveal, and **D. utahense** (N.H. Holmgren) Reveal.

RESUMEN

Se necesitan seis combinaciones nuevas en *Dodecatheon* L. en el tratamiento del género en la *Flora of North America north of Mexico*: **D. clevelandii** Greene var. **gracile** (Greene) Reveal, **D. clevelandii** var. **insulare** (H.J. Thomps.) Reveal, **D. clevelandii** var. **patulum** (Kuntze) Reveal, **D. pulchellum** var. **macrocarpum** (A. Gray) Reveal, **D. pulchellum** var. **shoshonense** (A. Nelson) Reveal, y **D. utahense** (N.H. Holmgren) Reveal.

The following new combinations are required for a forthcoming treatment of *Dodecatheon* L. (Primulaceae) in volume 8 of *Flora of North America north of Mexico*. The rank of variety is used throughout following Holmgren (1994).

Dodecatheon clevelandii Greene var. **gracile** (Greene) Reveal, comb. nov. *Dodecatheon patulum* (Kuntze) Greene var. *gracile* Greene, Erythea 3:72. 1895. TYPE: U.S.A. CALIFORNIA. Santa Clara Co.: garden specimen obtained from root collected at Loma Prieta by J.B. Davy (Not found).

Dodecatheon clevelandii Greene var. **insulare** (H.J. Thomps.) Reveal, comb. nov. *Dodecatheon clevelandii* subsp. *insulare* H.J. Thomps., Contr. Dudley Herb. 4:134. 1953 (as "*insularis*"). TYPE: U.S.A. CALIFORNIA. Santa Barbara Co.: in chaparral along road to La Cumbre Lookout, 2.3 mi E of San Marcos Pass, Santa Inez Mts., 3000 ft., 25 Mar 1950, *H.J. Thompson 1079* (HOLOTYPE: DS; ISOTYPE: OSC).

Dodecatheon clevelandii Greene var. **patulum** (Kuntze) Reveal, comb. nov. *Meadia patula* Kuntze, Revis. Gen. Pl. 2:398. 1894. *Dodecatheon patulum* (Kuntze) Greene, Erythea 3:72. 1895. The earlier Greene name (Pittonia 1:211. 1888) is not valid as it was provisional when published. TYPE: U.S.A. CALIFORNIA. Alameda Co.: Livermore Valley, 23 Mar 1888, *E.L. Greene s.n.* (LECTOTYPE: NDG; ISOLECTOTYPE: DS), designated by H.J. Thompson, Contr. Dudley Herb. 4:135. 1953.

The variation within *Dodecatheon clevelandii*, as defined by Thompson (1953), is maintained with only the rank altered. The epithet var. *gracile* is equivalent to subsp. *sanctarum* (Greene) Abrams.

Dodecatheon pulchellum (Raf.) Merr. var. **macrocarpum** (A. Gray) Reveal, comb. nov. *Dodecatheon meadia* L. var. *macrocarpum* A. Gray, Bot. Calif. 1:467. 1876. TYPE: U.S.A. ALASKA. Valdez-Cordova Co.: Middleton Island, 2 Jun 1874, *W.H. Dall s.n.* (LECTOTYPE: GH). NOTE: The lectotype was incorrectly termed a "neotype" by Beamish, Bull. Torrey Bot. Club 82:364. 1955. Previously, H.J. Thompson (1953) had considered a W.H. Brewer specimen (*217*, GH) from the Santa Susana Mts., Ventura Co., California, to be the type even though Gray considered this specimen to be a "form" of his var. *macrocarpum*, and annotated the Brewer specimen "macrocarpum, laciniatum."

This phase of *Dodecatheon pulchellum* has long been known as subsp. *alaskanum* (Hultén)

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Hultén or subsp. *superbum* (Pennell & Stair) Hultén. As treated by Thompson (1953) and by Taylor and MacBryde (1978), it is the tetraploid, coastal expression that occurs from southern Alaska to Oregon.

Dodecatheon pulchellum (Raf.) Merr. var. **shoshonense** (A. Nelson) Reveal, comb. nov.
Dodecatheon pauciflorum (Durand) Greene var. *shoshonense* A. Nelson, Bot. Gaz. 54:143. 1912 (as *shoshonensis*). TYPE: U.S.A. IDAHO. Twin Falls Co.: Shoshone Falls, 26 Jul 1911, *A. Nelson & J. F. Macbride 1362* (HOLOTYPE: RM).

This variety of *Dodecatheon pulchellum* is found mainly in alkaline meadows on the foothills and valley bottoms of the northern Mojave Desert and Intermountain Region. In the latter area, var. *pulchellum* is a plant of the mountains. Only in the Pacific Northwest will one find var. *pulchellum* at lower elevations. The distinctive yellow pollen sacs of var. *shoshonense* are seen in populations of var. *pulchellum* in the Black Hills area of northeastern Wyoming and adjacent South Dakota. Welsh (2003) proposed two entities which are synonyms of var. *shoshonense*: subvar. *atwoodii* and subvar. *coriaceum*.

Dodecatheon utahense (N.H. Holmgren) Reveal, stat. nov. *Dodecatheon dentatum* Hook. var. *utahense* N.H. Holmgren, Brittonia 46:91. 1994. TYPE: U.S.A. UTAH. Salt Lake Co.: Moss Falls, Big Cottonwood Canyon, Wasatch Range, 13 Jun 1977, *N.H. Holmgren & P.K. Holmgren 8412* (HOLOTYPE: NY; ISOTYPES: BRY, UTC).

The work by Mast et al. (2001, 2004) demonstrated that varieties of *Dodecatheon dentatum* Hook., recognized by Holmgren (1994), should be regarded as distinct species. Accordingly three widely disjunct entities are now accepted: *D. dentatum* mainly on the eastern slope of the Cascade Range from south-central British Columbia to central Washington, with disjunct populations along the western portion of the Columbia River, the Columbia River Gorge of both Oregon and Washington, northeastern Oregon (Wallowa Co.), and in northern Idaho; *D. ellisiae* Standley of north central New Mexico in the mountains of Bernalillo, Sandoval and Torrance cos., and in southeastern Arizona in southern Apache, Greenlee, southern Graham, and northeastern Santa Rita cos.; and *D. utahense*, a narrow endemic confined to Big Cottonwood Canyon, Salt Lake Co., Utah.

The recent molecular work on *Primulaceae* by Mast et al. (2001, 2004) and others (Källersjö et al. 2000; Martins et al. 2003; Trift et al. 2002) has shown that recognition of *Dodecatheon* creates a paraphyletic *Primula*. Accordingly, Mast and Reveal (2006) transferred all of the entities assigned to *Dodecatheon* to *Primula*.

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Book Review

Susanna Lyle. 2006. **Fruit and Nuts.** (ISBN 0-88192-759-7, hbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax.). $59.95, 480 pp., color photos, figures, glossary, bibliography and index, 8 1/4" × 11 1/4".

Have you ever looked at strange food in the grocery produce aisle and wondered which part you can eat? Or what preparation is needed to eat it? The new book *Fruit and Nuts* by Susanna Lyle will be a handy book to reference. Over two hundred food plants are presented in *Fruit and Nuts* along with details on floral structures, cultivation and uses. To help visualize the details, the book also includes over three hundred fantastic color photographs and images.

Fruit and Nuts opens with a very informative section that introduces the readers to the various aspects of fruit and nuts and their production. Plant classification and reproduction are covered in such a way that any reader can understand, and more detail can be found for bolded words in the glossary of the book. Lyle gives readers botanical definitions of fruit and nut types with plant examples and accented by color illustrations depicting nut and fruit structures. Additional information in the introductory section are overviews of plant types by global region, cultivation, propagation and the health benefits of nuts and fruits.

The majority of the text is the fruit and nut "encyclopedia" in alphabetical order by specific epithet from *Acer saccharum* (sugar maple) to *Zizyphus jujuba* (jujube). It should be noted that a few non-fruit nut items are included, such as syrup from sugar maples and eucalyptus. Each fruit or nut entry contains a crisp color image of the edible portion of the plant along with descriptions, structure, harvesting methods, cultivation, propagation and other relative species. A side box for each entry lists uses such as food, nutritional value, alternative uses and ornamental value. The descriptions are very thorough and easy to read. An appendix covers plants for differing growth conditions/uses such as ornamental and health benefits. There is also a glossary, bibliography by topic and an index.

Fruit and Nuts by Susanna Lyle is a fun and informative book with great value to those in food sciences, horticulture, gardening food plants or anyone with a general interest in learning more about the fruits and nuts consumed around the world. The text is thorough, easy to read, and is well illustrated with both color illustrations and color photographs. These illustrations and photographs are fantastic in helping readers to determine the edible portions of many potentially unknown fruits and nuts. This could be a wonderful reference book or gift for cooks, horticultural students or "foodies" in general.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

ERICAMERIA NAUSEOSA SUBSP. *AMMOPHILA* (ASTERACEAE), A NEW RABBITBRUSH FROM THE SAN LUIS VALLEY OF COLORADO

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ABSTRACT

A previously undescribed, distinctive subspecies of rabbitbrush has been recently discovered in south-central Colorado where it is the dominant plant on sandsheet and is frequent on low sand dunes. It is here named *Ericameria nauseosa* subsp. *ammophila*. A detailed description is given. Comparisons are made with related taxa, and a key is provided.

RESUMEN

Se ha descubierto recientemente una nueva subespecie de chamiso en el centro-sur de Colorado dinde es la planta dominante en el arenal y frecuente en dunas bajas. Se ha nombrado como *Ericameria nauseosa* subsp. *ammophila*. Se aporta una descripción detallada. Se hacen comparaciones con otros taxa relacionados, y se aporta una clave.

One of the most widespread species in western North America is the rabbitbrush *Ericameria nauseosa* (Pallas ex Pursh) Nesom & Baird. It ranges from southern Canada south to northern Mexico and from the Dakotas, Kansas, and Texas west to Washington and California. This rabbitbrush was long known as *Chrysothamnus nauseosus* (Pallas ex Pursh) Britton. H.M. Hall (with F. E. Clements) monographed *Chrysothamnus* in 1923 and *Haplopappus* in 1928, and his views held for many years. However, when the North American species of *Haplopappus* were demonstrated not to be closely related to the South American species (which included the type species for the genus), several sections of Hall's North American *Haplopappus* were recognized as separate genera. One such genus is *Ericameria*. Some species of *Chrysothamnus*, such as *C. nauseosus*, have long been noted for their close similarity to *Ericameria*. When DNA data suggested that the traditional *Chrysothamnus* was not monophyletic, Nesom and Baird (1993) transferred four of its species, including *C. nauseosus*, to *Ericameria*.

Anderson (1986a) recognized 22 subspecies of *C. nauseosus*, whereas Nesom and Baird (1993) recognized two subspecies of *E. nauseosa* (i.e., subsp. *nauseosa* and subsp. *consimilis*) and several varieties. Now, a new infraspecific taxon of *E. nauseosa* is to be described. Should it be a variety or a subspecies? Nesom and Baird (1993) emphasized the category of variety, but I believe my rationale for use of subspecies (Anderson 1986b) is solid, and I therefore describe the new subspecies, *Ericameria nauseosa* subsp. *ammophila*, below. Variability in the species is great, and my extensive study of the group in the field and in the herbarium has convinced me to apply infraspecific names to only the more significant morphotypes. It is surprising that this new subspecies has escaped recognition for so long. Specimens of it were not represented in the more than 12,000 collections of *C. nauseosus* that I studied from 56 herbaria (including COLO, CS, NCM, RM, and UNM) about 30 years ago.

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I intend to make appropriate subspecific combinations in *Ericameria nauseosa* in a future paper so that variation within the wider ranging subspecies can then be recognized through quadrinomials. Some argue that quadrinomials are cumbersome, but at an applied level, some field workers may wonder why the populations in their regions have the same subspecific name that is applied to somewhat different-looking populations in other regions, and quadrinomials would help them see the relationships. Therefore, in the discussion section of the present paper, I will use subspecies names as they occurred in *Chrysothamnus nauseosus* (Anderson 1986a) for comparative purposes.

Ericameria nauseosa (Pallas ex Pursh) Nesom & Baird subsp. **ammophila** L.C. Anderson, subsp. nov. (**Figs. 1, 2**). TYPE: UNITED STATES. COLORADO. Saguache Co.: abundant on sandsheet of Baca National Wildlife Refuge, ca. 4.5 air mi SW of Crestone, elev. 2528 m (7600 ft), Lat. 37° 56' 12" N, Long. 105° 44' 29" W, 2 Sep 2005, *L.C. Anderson 21,303* (HOLOTYPE: BRIT; ISOTYPES: COLO, FSU, NY).

Frutices usque ad 14 dm alti caulibus multis fastigiatis tomentulosis et foliis flavovirentibus; folia linearia, 20–45 mm longa, 0.6–1.2 mm lata; inflorescentiae paniculatim cymosae; capitula cylindrica, 9.3–14 mm alta, straminea, bracteis exterioribus ovatis, tomentulosis vel glabratis, interioribus oblongis, glabris, apicibus obtusis vel acuminatis; flosculi disci 5, pallide flavi, corollibus 10.5–13 mm longis, lobis plerumque minus quam 1 mm longis, aliquot pilis sparsis in tubo corollae usque ad 3.5 mm longis, appendicibus styli quam lineis stigmaticis plerumque longioribus, plerumque longioribus; achaenia pubescentia.

Fastigiate shrubs, 3.5–7(–14) dm tall, usually broader than tall from considerable branching; ultimate flowering branches (8–)10–20(–25) cm tall, shallowly grooved, yellowish-green with compact tomentum, somewhat viscidulous. Leaves alternate, entire, linear, stiffly ascending or slightly spreading, (20–)25–30(–45) mm long, only slightly shorter toward stem tips, (0.6–)0.9–1.0(–1.2) mm wide, subterete with adaxial groove, light green, pubescence of sparse, compact, tomentum and a few longer, villous hairs. Inflorescences tightly congested paniculate cymes; heads cylindrical, (9.3–)11–12.5(–14) mm tall, (2–)2.5(–3) mm wide, stramineous; receptacle with central cusp (0.7–)1–2(–2.5) mm long. Phyllaries (15–)16–18(–20), in vertical rows, outermost (lowest) bracts ovate, 1.2–2 mm long, tomentulose to glabrate, inner bracts oblong, 8–10 mm long, glabrous with ± ciliate margins (few cilia to 0.4 mm long), weakly keeled, tips (rarely with tufted pappilae 0.1 mm long) obtuse to acuminate. Disk flowers 5; corollas (10.5–)11.5–12.5(–13) mm long, narrowly cylindric gradually flaring to erect lobes (0.6–)0.7–1.0(–1.3) mm long, yellow, sparse hairs on tube generally 0.2 mm long but a few 1–2(–3.5) mm long; styles (13–)14–16(–17.5) mm long, style branches 3.9–4.7 mm long, the stigmatic lines more or less equal to branch tips in length (40–56%), anthers 4 mm long with appendage 0.8–0.9 mm long; mature achenes cylindric, 5-nerved (the nerves when noticeable because of brownish material in associated secretory canals), 4.5–6(–6.8) mm long, sericious with hairs (0.4–)0.5–0.7(–1.0) mm long, pappus (9–)10–11(–12.5) mm long, finely barbellate, white.

Phenology.—A few shrubs of the new subspecies start to bloom in late August; most are in full bloom in mid-late September, whereas *E. nauseosa* subsp. *consimilis*, or var. *oreophila* (A. Nelson) G.L. Nesom & G.I. Baird, found in nearby more mesic, saline sites, blooms earlier in August.

Habitat.—The new rabbitbrush occurs (in descending frequency) on: sandsheet, dune fields, stabilized sand dunes, and sandy soil of open pinyon-juniper (old dunes?). The term sandsheet is variously defined by geologists; here it refers to flat expanses of stabilized coarse, poorly sorted sands that occur extensively along the margins of the high dunes of the Great Sand Dunes National Park (tallest in North America). The rabbitbrush is the dominant plant (hiding nearly equally frequent grasses) on the sandsheet, and sandsheet



FIG. 1. Close-up of of flowering branches of *Ericameria nausosa* subsp. *ammophila* showing characteristic yellowish-green stems, nearly glabrous involucres, and short corolla lobes.

rabbitbrush is very appropriate as a common name for this new subspecies (whose epithet *ammophila* means 'sand loving'). From a distance, the vegetation on much of the Baca National Wildlife Refuge appears as a more or less evenly spaced, 'unbroken sea' of sandsheet rabbitbrush. Dune fields are generally flat but have some undulating topography. The sandsheet rabbitbrush occurs at elevations from 2518 to 2735 m (7550 to 8200 ft).

Associated species.—The grasses, *Achnatherum* (*Oryzopsis*) *hymenoides* (Roem. & Schult.) Barkworth and *Chondrosum* (*Bouteloua*) *gracile* H.B.K., are usually co-dominants with the sandsheet rabbitbrush. The following are found at one or more sites: *Chrysothamnus greenei* (Gray) Greene, *Eriogonum cernuum* Nuttall, *Heterostipa* (*Stipa*) *comata* (Trin. & Rupr.) Barkworth, *Ipomopsis longiflora* (Torr.) V. Grant, *Nuttallia* (*Mentzelia*) *rusbyi* (Wooton) Rydb., *Opuntia polyacantha* Haworth, *Psoralidium lanceolatum* (Pursh) Rydb., *Rhus trilobata* Nuttall, *Senecio multilobatus* Torr. & Gray, *Sporobolus cryptandrus* (Torr.) Gray, and *Yucca glauca* Nuttall. The flora of the sandsheet-sandhill ecosystem of this region is sparse in numbers of taxa.

Additional collections: **COLORADO. Alamosa Co.:** Great Sand Dunes National Park Visitor's Center, 2 Sep 2005, *L.C. Anderson 21,280* (FSU); sand sheet by road to Medano Ranch, 9.9 mi E of Hwy 17, 2 Sep 2005, *L.C. Anderson 21,291* (FSU). **Saguache Co.:** ca. 3.7 mi SSE of Crestone, 21 Aug 2001, *J. Erdman 0113* (FSU), 6 Sep 2001, *J. Erdman 0116* (FSU), 27 Sep 2001, *J. Erdman 0121* (FSU); 1 Sep 2005, *L.C. Anderson 21,276* (FSU); rd to San Isabel Canyon trailhead, 21 Aug 2001, *J. Erdman 0114* (FSU); 7 Sep 2001, *J. Erdman 0119* (FSU); 28 Sep 2001, *J. Erdman 0123* (FSU); near Pinyon Flats, Great Sand Dunes National Park, 2 Sep 2005, *L.C. Anderson 21,286* (FSU); dune field near "Oxbow Pond" between Spanish Creek and Cottonwood Creek, 22 Aug 2001, *J. Erdman 0115* (FSU); 7 Sep 2005, *J. Erdman 0118* (FSU); 27 Sep 2001, *J. Erdman 0122* (FSU); 2 Sep 2005, *L.C. Anderson 21,301* (FSU).

DISCUSSION

The sandsheet rabbitbrush (subsp. *ammophila*) is perhaps most closely related to subsp. *nitidus* L.C. Anderson which occurs in northern Arizona and adjacent New Mexico. The two share the features of yellow-green foliage and stramineous, shiny involucres. They differ in geography and habitat (subsp. *nitidus* prefers sandy gravels of dry stream beds) and in that subsp. *ammophila* fomrs shorter shrubs usually 35–70 cm tall (60–150 cm in subsp. *nitidus*), and has flowering stems fastigiate and more crowded than in subsp. *nitidus*, leaves usually 25–30 mm long and 1 mm or less wide (30–50 by 1–1.5 mm in subsp. *nitidus*), corollas mostly 11.5–12.5 mm long (9.5–11 mm in *nitidus*), unusually long trichomes on the corolla tubes and pubescent achenes (usually glabrous in *nitidus*). Subspecies *turbinatus* M.E. Jones is like the sandsheet rabbitbrush in height and branching, but it occurs generally in sandy regions of the Great Basin and has mostly longer involucres with tomentulose phyllaries that are acute to acuminate (phyllaries in subsp. *ammophila* are mostly glabrous with obtuse to acute tips), and shorter corollas with lobes that are villous. Subspecies *consimilis* (i.e., var. *oreophila* of Nesom & Baird 1993) rarely grows with subsp. *ammophila*, but subsp. *consimilis* usually grows in more saline or disturbed (mesic) habitats in this region, and it differs in forming generally taller, narrower shrubs with darker green foliage and smaller involucres and flowers. The unusually long hairs (up to 3.5 mm) on the corolla tubes of the sandsheet rabbitbrush are 10 times longer than any others found in the species or in all of the former genus *Chrysothamnus* (Anderson 1970).

A portion of the Urbatsch et al. (2006) key to the varieties (listed here as subspecies) of *Ericameria nauseosa* is given below with the new subspecies included; subsp. *ammophila* shares a couplet with subsp. *bernardinus*, but the two are not closely related (ecologically, geographically, or taxonomically within the species).



Fig. 2. Sandsheet rabbitbrush in foreground on stabilized dune in Great Sand Dunes National Park (in front of lower shoulder of large dune devoid of vegetation) with the Sangre de Cristo Mountains in the background.

1. Cypselae glabrous (plants 60–150 cm; involucres 10–12.5 mm) _____ subsp. **nitidus** (in part)
1. Cypselae hairy.
   16. Corolla lobes villous (sometimes sparsely).
      19. Leaf blades 30–50 mm, faces glabrate _____ subsp. **nitidus** (in part)
      19. Leaf blades 10-20 mm, faces tomentulose _____ subsp. **turbinatus**
   16. Corollas lobes glabrous.
      23. Phyllaries usually glabrous, outer sometimes sparsely hairy.
         24. Corollas 10–12[13] mm; involucres [9.3]10–14 mm.
            [24a. Corolla lobes 1.7–2.3 mm] _____ subsp. **bernardinus** (in part)
            [24a. Corolla lobes 1 mm or less] _____ subsp. **ammophila**
         24. Corollas 6–9+ mm; involucres 6–10 mm _____ subsp. **consimilis** [i.e., var. **oreophila**]

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A NEW SPECIES OF *BOLTONIA* (ASTERACEAE) FROM THE RIDGE AND VALLEY PHYSIOGRAPHIC PROVINCE, U.S.A.

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ABSTRACT

Boltonia montana, a new species from depression wetlands and riverine habitats in the Appalachian Mountains of Virginia, New Jersey, and Pennsylvania, is described. This taxon has most often been collected under the name *Boltonia asteroides* (L.) L'Her. due to its relatively large heads which are usually few in number, and vegetative similarities. Cypselae morphology of the new taxon, however, is dissimilar to that of *B. asteroides* and most closely resembles *Boltonia caroliniana* (Walt.) Fern., a species characteristic of coastal plain and piedmont bottomlands of the Carolinas and Virginia. *Boltonia montana* differs from the latter taxon in terms of inflorescence structure, head dimensions, ray color, phyllary morphology and size, plant stature, and leaf shape. Evidence of its distinctiveness is provided and its wetland habitat is discussed.

RESUMEN

Se describe ***Boltonia montana***, una nueva especie de las tierras húmedas de depresiones y hábitats ribereños de los Apalaches de Virginia, Nueva Jersey, y Pennsylvania. Este taxon se ha colectado la mayoría de las veces con el nombre de *Boltonia asteroides* (L.) L'Her. Debido a sus cabezuelas relativamente grandes que están usualmente en un número pequeño, y similitudes vegetativas. La morfología de las cipselas del nuevo taxon, sin embargo, es diferente de la de *B. asteroides* y se parecen mucho más a *Boltonia caroliniana* (Walt.) Fern., una especie característica de la llanura costera y base del pie de monte de las Carolinas y Virginia. *Boltonia montana* difiere de este último taxon en términos de estructura de la inflorescencia, dimensiones de la cabezuela, color de los radios, morfología y tamaño de los filarios, tamaño de la planta, y forma de la hoja. Se aportan pruebas de su diferenciación y se discute su hábitat de zonas húmedas.

INTRODUCTION

The first author was alerted to the presence of a taxonomically problematic *Boltonia* in Augusta County, Virginia (Ridge and Valley physiographic province) by Gary P. Fleming, J. Christopher Ludwig (Virginia Department of Conservation and Recreation, Division of Natural Heritage), and Thomas F. Wieboldt (Massey Herbarium, Virginia Polytechnic Institute) in late 2001. This plant had been identified as *Boltonia asteroides* by collectors, but certain details of the plants, particularly those of cypselae and phyllaries, indicated the Augusta County plants were not a good fit for that taxon.

Subsequent investigations of the taxonomic literature, herbarium material, and living populations of *Boltonia* led to the realization that the plants from sinkhole ponds (dolines) in the Virginia mountains possessed a unique set of characters. During morphological and molecular investigations of the Virginia plants, correspondence with the second author led to the discovery of morphologically similar herbarium specimens collected from the Ridge and Valley physiographic province of northwestern New Jersey and eastern Pennsylvania. Field studies in the early 1980s and late 1990s by David Snyder and Kathleen Strakosch Walz of the New Jersey Natural Heritage Program uncovered or reinventoried the *Boltonia* populations in the northwestern part of that state and provided much data

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on the plants discussed here. Subsequent herbarium and field investigations of the Virginia, New Jersey, and Pennsylvania plants confirmed that these plants belonged to the same taxon. It is described here as new.

Boltonia montana J.F. Townsend & V. Karaman-Castro, sp. nov. (**Figs. 1, 2**). TYPE: U.S.A. NEW JERSEY. Sussex Co.: Muckshaw pond complex, located 3.2 km SW of Newton and 1.4 km W of US 206, nearly dry, herb-dominated sinkhole pond, 3 Oct 2005, *J.F. Townsend 3570* (HOLOTYPE: US; ISOTYPES: MO, NY, VPI).

Boltonia asteroides (L.) L'Her. primo adspectu maxime simile ob capitulis magnus et paucus sed acheniis glabris, alis et pappus aristis destitutis a *Boltonia caroliniana* (Walt.) Fern. similis. Phyllariis costa angustata, herbaceous et distalis viridis.

Glabrous, perennial herbs 1.2–15 dm tall, ascending to erect (often prostrate in lower portion to ca. 1/2 stem length, sometimes rooting at nodes in this section). **Stems** glabrous, light to yellowish-green, ribbed with yellow or golden striations (more prominent in upper 1/2 of plants), branching above into small, simple, corymbose panicles to diffusely paniculate in larger plants. **Leaves** basal and cauline, glabrous; basal leaves 0–18, alternate, in a rosette, oblanceolate to oblanceolate-spatulate, attenuated at the base (where often slightly widened), dark green or blue-green, often whitish or reddish colored at the base, with prominent, lighter-colored midrib and inconspicuous, arcuate secondary veins, apices bluntly rounded, mucronulate to entire, 1–17.5 cm long, 0.1–2 cm wide; cauline leaves oblanceolate to obovate or spatulate, bases sessile, often partially clasping, apices rounded to acute, mostly with mucronulate tips, appearing entire but minutely serrulate with narrow, whitish, cartilaginous margin, 2.7–11 cm long, 0.5–1.9 cm wide, sometimes with smaller leaves clustered at nodes. **Capitulescences** corymbose-paniculate, few-headed (1–25) in average individuals, many-headed (–100+) in large individuals. **Peduncles** bracteate, 0.5–11.8 cm long, 0.5–1.1 mm thick, bracteal leaves oblanceolate to obovate or oblong, tips obtuse to acute, mucronulate, 0–5 per pedicel, 0.1–9.7 cm long, 0.02–1.4 cm wide. **Involucre** 5.2–7.8 mm tall, 6.0–11.3 mm wide; **phyllaries** 30–60, lance-attenuate, serrulate to lacerate, in 2–4 series, 2.5–4.4 mm long, 0.4–0.9 mm wide, midrib 0.12–0.3 mm wide (1/10–1/5 of phyllary width), proximally whitish, distally green; **receptacles** conic, naked, 1.9–3.0 mm tall, 1.9–3.8 mm wide. **Ray flowers** 27–46, pale lavender to pinkish (-white), corollas glabrous, 4–5 nerved with golden or amber colored veins, 8.1–12 mm long, 0.8–1.9 mm wide, tubes 0.45–0.95 mm long; styles 1.3–2.45 mm long, style branches 0.25–0.4 mm long, cypselae glabrous, narrowly oblong, triquetrous, with 1 adaxial and 2 abaxial ribs, often slightly curved outward, 1.25–2.05 mm long, 0.5–0.9 mm wide, wings vestigial or absent, 0–0.05 mm wide; pappus awns reduced to a crown of minute scales, 0–0.1(–0.4) mm long, **Disk flowers** 220–350, pale yellowish green to pale yellow-white as cypselae mature, suture lines pale amber, disk appearing more yellowish during anthesis, corollas glabrous, 1.1–2.3 mm long, tubes 1.0–1.85 mm long, lobes 0.15–0.36 mm long; stamens included to exceeding corolla length by 0.4 mm, anthers 0.65–1.1 mm long, appendages 0.15 mm long, styles 1.05–2.55 mm long, style branches 0.2–0.4 mm long, cypselae glabrous, narrowly oblong, strongly flattened laterally with two marginal ribs, 1.3–1.9 mm long, 0.55–1.25 mm wide, wings vestigial, 0–0.09 mm wide, pappus awns usually reduced to a crown of minute scales 0–0.1 (–0.6) mm long.

Distribution.—Distributed in sinkhole pond habitats and associated riversides and streamsides of the Ridge and Valley physiographic province in western Virginia, northwestern New Jersey, and eastern Pennsylvania.



FIG. 1. *Boltonia montana* J.F. Townsend & V.Karaman-Castro. Illustration based on material collected in Sussex County, New Jersey. **1.** Habit. **2.** Ray cypselae. **3.** Disk cypselae. **4.** Head. **5.** Outer phyllary (abaxial view). **6.** Ray corolla. **7.** Disk corolla. Scale bar equals 1mm except in 1 (= 1 dm) and 4 (=1 cm).



FIG. 2. Low-growing individual of *Boltonia montana* with *Eriocaulon aquaticum*, Augusta County, Virginia. Photo by Gary P. Fleming.

Etymology.—The name refers to the species' montane habitats.

Phenology and development.—Flowering primarily occurs from early August to mid-October with precocious plants flowering in July, especially during dry years or in dry microhabitats. Hydrologic fluctuations in the species' sinkhole pond habitat can have a dramatic effect on the timing of flowering in a population. Even when water levels remain high enough to inundate these ponds during the growing season, seeds are capable of germination and rosettes may develop while still under water (Lassen and Hamilton 2003; David Snyder pers. comm. 2006) but the plants may not develop further, and if inundated for successive years the plants may die (David Snyder, pers comm. 2006). Autumnal plants produce basal offsets nearly identical in appearance to the rosettes produced by young plants. In the case of reclining or ascending plants of *Boltonia montana*, adventitious roots may form at the nodes as autumn approaches. In many cases, these nodes also produce leafy offsets complete with root systems. During collection of flowering or fruiting plants, these vegetative propagules are often dislodged due to their weak attachment to the parent plant.

A concentric gradient of environmental conditions is created in these sinkholes by fluctuating hydrology and sloping shorelines. It is therefore possible to find several co-occurring growth stages of *Boltonia montana*. Recent field work in New Jersey with Natural Heritage Program Botanist David Snyder and Ecologist Kathleen Strakosch Walz (autumn 2005) was conducted following a long period of pond inundation. On the pond margins that were not recently inundated, relatively well-developed plants (with flowers, fruits, and basal offsets) were found. In more recently inundated portions of the ponds, large numbers of *Boltonia* rosettes were found. These plants were either newly germi-

nated seedlings, rosettes persisting from a previous germination event, or vegetative offsets now independent of the parent plant. Regardless of origin, these rosettes were unable to flower or produce fruit before the end of the growing season due to their exceptionally late emergence (September–October). In general, when pondshores are exposed as groundwater levels drop after such periods of inundation, new plants develop from the seed bank (David Snyder, pers. comm. 2006).

Observations indicate that Smith and Mettler's (2002) description of the life cycle of the Federally Endangered *Boltonia decurrens* (Torr. & A. Gray) Wood provides a framework for understanding the life cycle of *Boltonia montana* as well: "Although *B. decurrens* is a perennial under optimal conditions, various life stages may behave as winter annuals (winter seedlings bolt, flower, and senesce the following summer), as summer annuals (summer seedlings bolt, flower, and senesce the same summer), or as biennials (ca. 25 percent of spring seedlings overwinter as rosettes that bolt, flower, and senesce the following summer)." Such a patchwork of potential strategies makes sense for a species adapted to the highly variable flood pulse of Midwestern rivers (*B. decurrens*) as well as the dramatic hydrological fluctuations of isolated wetland systems (*B. montana*).

HABITAT AND DISTRIBUTION

Boltonia montana is known from localized sections of the Ridge and Valley physiographic province in three U.S. states: Virginia (one county), New Jersey (two counties), and Pennsylvania (one county). All occurrences are found within areas of gently sloping, rolling, or nearly level ground between 149 and 488 m (490–1600 ft) altitude (Walz et al. 2001, Va. Division of Natural Heritage files), but many of the New Jersey ponds are surrounded by rough terrain with extensive bedrock outcrops (Kathleen S. Walz, pers. comm. 2006).

The sinkhole pond complexes which support this species span an area measuring roughly 14× 15 km near Newton, New Jersey and 5.25 × 4.5 km near Waynesboro, Virginia. Within these areas, plants are known from a total of 36 sinkhole ponds and lakes (22 in New Jersey and 14 in Virginia; Va. Division of Natural Heritage files; David Snyder, pers comm. 2006). Although the vast majority of the records for this new taxon come from isolated wetlands, a very few have been found along rivers. Besides two collections made the same day in 1936 along the South River in Virginia, the only other such collections were made in 1864 (1 specimen) and 1865 (1 specimen) along the Susquehanna River in Dauphin County, Pennsylvania—apparently the only observations of this species in Pennsylvania. The Virginia occurrence was taken from an area extremely close to, and just downslope from, a sinkhole pond complex known to contain *Boltonia montana*, while the disposition of the Pennsylvania material relative to potential sinkhole pond seed sources is unclear. It is assumed here that only occasional plants become established in such riverine habitats from nearby "parent" populations. The lack of additional collections at least indicates that such riverine habitats are rarely occupied.

Like *Boltonia montana*, many species seemingly defined by their isolated wetland habitat are occasionally found in other community types, indicating that their affinity for these ponds is not restrictive. Examples include the co-occurring *Helenium virginicum* Blake in Virginia, which is almost entirely restricted to sinkhole ponds but also occurs in a wet meadow of the nearby South River (Va. Division of Natural Heritage files). The diminutive sedge *Fimbristylis perpusilla* Harper ex Small and Britt.was also thought to be a strict pond endemic and functions as such in most localities, but discoveries in North and South Carolina (Leonard 1981, 1987), established the species as an occupant of river-

ine "draw-down" bars, banks, and sloughs as well. A final example involves *Boltonia decurrens*, a perennial species of floodplains in the Illinois River valley (Stoecker et al. 1995) which was originally dependent on natural flood pulses for habitat maintenance and germination. Most of the habitats occupied by this species have been described as wet prairies or bottomland communities of various types, but McClain et al. (1997) also reported the species from "sand ponds" near the Illinois River in Cass and Mason counties, Illinois. They described water levels in the ponds as fluctuating in response to the local aquifer rather than overbank flooding, but it is not known to what degree human manipulation of the river has lessened the importance of this water source in the ponds.

The sinkhole pond habitats occupied by *Boltonia montana* are ultimately formed by the solution of underlying carbonate bedrock and subsequent volume loss or collapse of this foundation (Fleming & Van Alstine 1999; Walz et al. 2001). The habitat types found within sinkhole ponds in Virginia and New Jersey are floristically and physically different, owing to their means of origin, Pleistocene history (glacial scouring and surficial geologic deposits), and distance of calcareous materials from the soil surface.

In Virginia, weathering of limestones and dolomites of the Cambrian Shady and Elbrook Formations is ultimately responsible for the formation of these pond features, but a deep overburden of relatively acidic, infertile soils covers these carbonate rocks to a depth of 30 to 150m (Fleming & Van Alstine 1999). This phenomenon is similar to that described in Maryland and West Virginia by Bartgis (1992) who studied ponds supporting the rare pond endemic *Scirpus ancistrochaetus* Schuyler. In Virginia, surficial deposits are the result of alluvial fan formation along the western slopes of the Blue Ridge mountains. Materials range from quartzite cobbles and boulders to sand, silt, and clay and range from the late Pleistocene to Pliocene or Miocene in age (Whittacar et al. 1999). Due to the depth where the carbonate rocks reside, soil and water chemistry of the ponds is acidic (pH 3.9–4.0 at 0–30 cm). Soils are predominantly gray to blackish clays or clay loams with lighter colored mottling evident below 3 to 10 cm. This clay, weathered from metasiltstone and phyllite alluvium, impedes drainage but most ponds draw down as the growing season progresses and evapotranspiration increases. Although some of these sinkholes are relatively stable hydrologically, *Boltonia montana* is almost exclusively found in those ponds with highly variable and unpredictable water levels. The *Boltonia montana* "zone" in these ponds is typically doughnut-shaped and extends from the rim of the pond to the edge of the most deeply flooded portion of the basin (Fig. 3).

The community types occupied by the species in Virginia are the *Quercus palustris / Panicum rigidulum – Panicum verrucosum – Eleocharis acicularis* Wooded Herbaceous Vegetation Association and the *Cephalanthus occidentalis / Polygonum hydropiperoides – Glyceria acutiflora – Proserpinaca palustris* Shrubland Association (Grossman et al. 1998; NatureServe 2005). The former community type is endemic to Virginia and assigned a rarity rank of G1G2 (NatureServe 2005). The latter type is somewhat more widespread (ranked G3?/S1) but is considered endemic to mid-Atlantic region. These communities are open-canopied except on pond edges, where the forest canopy can provide partial shading. Associated species in these communities include *Quercus palustris*, *Nyssa sylvatica*, and *Cephalanthus occidentalis* (mostly occurring on pond margins), *Panicum rigidulum* var. *rigidulum*, *P. philadelphicum*, *P. verrucosum*, *Eleocharis acicularis*, *Eleocharis melanocarpa*, *Eriocaulon aquaticum*, *Lysimachia hybrida*, *Ludwigia palustris*, *Leersia oryzoides*, *Hypericum boreale*, and the federally Threatened *Helenium virginicum*. In addition to relatively undisturbed sinkhole ponds, *Boltonia montana* is also found with



FIG. 3. Sinkhole pond habitat of *Boltonia montana* in Augusta County, Virginia. Photo by Gary P. Fleming.



FIG. 4. Zone occupied by *Boltonia montana* along margin of "Piggyback Pond," Warren County, New Jersey. Photo by John F. Townsend.

H. virginicum in several altered ponds, most of which are in pasture. As a result, these ponds include a number of species with broader habitat associations such as *Juncus effusus, J. canadensis, J. tenuis, Bidens frondosa, B. polylepis, Ambrosia artemesiifolia, Phytolacca americana, Daucus carota, Vernonia noveboracensis, Digitaria ischaemum, Echinochloa crusgalli, Datura stramonium, Eclipta alba,* and *Erigeron annuus,* among others.

The New Jersey ponds are decidedly calcareous, occurring within a glaciated karst landscape on dolomite bedrock. These sinkholes are found within the Ordivician Allentown Dolomite and Beekmantown Dolomite formations, with surficial deposits composed of a glacial till/ bedrock complex. In rare instances, *Boltonia montana* populations may be found on glacial outwash (kettles). In all cases, the amount of overburden present is significantly less than (and more alkaline than) that found in the Virginia pond complexes, and the carbonate rocks or marl deposits are usually at or near the soil surface, providing a slightly acidic to mildly alkaline soil environment (pH 6.2–7.8 at 0–30 cm; Walz et al. 2001). In New Jersey the presence of marl and *Chara* spp. are characteristic of the sinkhole pondshore habitat for *B. montana.* Although soil chemistry of these ponds differs from Virginia examples, dramatic fluctuations in the seasonal water table (as much as 5.5 m per season in New Jersey) are characteristic of ponds occupied by the species in both states. Soils in New Jersey are shallow silt loams, silty clay loams, silty clay, or rarely silt marl overlaying clay or bedrock. Marly muck or peat soils are also present in rare instances and small dolomite rocks are often found on the surface (Walz et al. 2001). Deep marl deposits often occur in the center of ponds occupied by *B. montana*, but as with the Virginia populations, *Boltonia montana* usually occurs in a distinctive doughnut-shaped zone or "ring" between the pond edge and the more frequently and deeply flooded pond center (Fig. 4).

The community type occupied by the new taxon in New Jersey is the *Boltonia asteroides* var. *asteroides* – *Symphyotrichum racemosum* – *Mentha arvensis* Herbaceous Vegetation Asociation (Grossman et al. 1998; Natureserve 2005; Walz et al., 2001), a community type that is ranked G1G2 by Natureserve (the naming of *B. montana* will involve a concomitant change in the community name). Characteristic species in this community type include: *Asclepias incarnata, Cyperus strigosus, Carex cryptolepis, C. lurida, C. typhina, C. viridula, Cuphea viscosissima, Eleocharis palustris, Eragrostis frankii, Eupatorium perfoliatum, Iris versicolor, Dichanthelium acuminatum var. fasciculatum* (=*Panicum lanuginosum* var. *tennesseense*), *Panicum capillare, Panicum rigidulum* var. *pubescens* (=*Panicum longifolium*), *Polygonum amphibium, Sium suave,* the green algae *Chara* spp., and the bryophytes *Hypnum lindbergii, Campylium stellatum,* and *Amblystegium serpens* (Walz et al. 2001). Species in this community type which are rare in New Jersey include: *Boltonia montana, Carex bebbii, C. cryptolepis, C. haydenii C. retrorsa, C. typhina, C. viridula, Eleocharis quadrangulata,* and *Eragrostis frankii* (Snyder 2005).

Many endemic wetland plant species are confined to habitats with widely fluctuating hydroperiods, and it has been suggested that the ability of these species to tolerate such stressful conditions releases them from competition with other taxa (Knox 1997). This aspect of the life history of *Helenium virginicum* was studied by Knox (1997), who concluded that the ability of plants to tolerate the twin stressors of potentially toxic soils and fluctuating hydrology was rare and contributed to the species' endemism. *Boltonia montana* and *H. virginicum* co-occur at several Virginia ponds where these adverse soil conditions (low pH and elevated levels of aluminum and arsenic) have been documented, with the remainder of Virginia ponds thought to have similar soil characteristics. Data

on soil relations in the New Jersey ponds are incomplete, but indications of high aluminum, calcium, and magnesium levels have been found and erratic water level fluctuations are well-documented there (Walz et al. 2001).

Additional specimens examined: **NEW JERSEY: Sussex Co.:** near Lake Grinnell, 17 Sep 1887 *N.L. Britton, s.n.*(NY); Swartswood Lake, 6 Jul 1907, *Philip Dowell 4951* (GH); low swale, Brighton, 4 Sep 1910, *K.K. Mackenzie 4778* (GH, NY); borders of pond E of Swartswood Lake, Aug 1911, *K.K. Mackenzie 4922* (NY, PH); border of Muckshaw Pond, Springdale, Aug 1917, *K.K. Mackenzie 7986* (NY); "Swallowhole Pond," 3.1 km E of Swartswood, 4.7 km NW of Newton, 3 Oct 2005, *J.F. Townsend 3556* (VPI, NCU, CLEMS); "Duck Pond," Swartswood State Park, 1.2 km N of Paulinskill, 5 km WNW of Newton., 3 Oct 2005, *J.F. Townsend 3557* (PH, PENN); "Frog Pond," Swartswood State Park, 1.75 km NNE of Paulinskill, 5 km WNW of Newton., 3 Oct 2005, *J.F. Townsend 3558* (NY); "Little Frog Pond," Swartswood State Park, 1.75 km NNE of Paulinskill, 5 km WNW of Newton, 3 Oct 2005, *J.F. Townsend 3559* (VPI); "Spring Lake," Swartswood State Park, 3.1 km NW of Newton, 2.1 km SE of Swartswood, 4 Oct 2005, *J.F. Townsend 3562* (BRIT, GMUF, GH); northernmost "Muckshaw Ponds," 1.6 km SW of Newton and 0.4 km W of US 206, 4 Oct 2005, *J.F. Townsend 3565* (MARY, WVA, VPI); "Muckshaw Ponds," 2 km SW of Newton and 0.6 km W of US 206, 4 Oct 2005, *J.F. Townsend 3566* (CHRB, PH, NY); "Muckshaw Ponds," 2.75 km SW of Newton and 0.6 km W of US 206, *J.F. Townsend 3569* (VPI, NCU, GMUF). **Warren Co.:** Muddy calcareous shores and flats, Shyster Pond, 24 Jul 1920, *K.K. Mackenzie, s.n.* (NY, PH); muddy shore of limestone sink pond, Johnsonburg, 4 Oct 1981, *D.B. Snyder 551-6PH*, (PH); "Piggyback Pond," located ca. 5 km NE of Blairstown and 1.6 km N of Squires Corner, *J.F. Townsend 3560* (GH, CLEMS, USCH); (Warren/Sussex Co. line) "Four-Angle Pond," located 1.6 km NW of Tranquility and 1.25 km SSW of Greendell, 3 Oct 2005, *J.F. Townsend 3561* (VPI). **PENNSYLVANIA. Dauphin Co.:** banks of the Susquehanna, near Dauphin, 2 Aug 1865, *C.F. Parker, s.n.* (NY); Harrisburg, Jul 1864, *I.C. Martindale, s.n.* (PH). **VIRGINIA. Augusta Co.:** Sandy, wet soil, bank of South River, vic. Lipscomb, 18 Jul 1936, *L.L. Carr 47* (GH); growing on bank of South River vicinity of Lipscomb, abundant in Stuart's Draft area around ponds and along South River, 18 Jul 1936, *E.S. Rawlinson 58A* (VPI); Kennedy Mt. Meadow, (unintelligible) bog, 14 Sep 1937, *L.L. Carr, s.n.* (PH); moist edge of pond (open sit.), vic. Lipscomb, 5 Aug 1938, *L.L. Carr 365* (GH); edge of dried up pond, Big Levels refuge, 8 Sep 1939, *A.B. Massey, s.n.* (VPI); Lipscomb Pond, in water, vicinity of Lipscomb, Shenandoah Valley, 8 Sep 1940, *E.P. Killip, 36069* (US); adjacent to Spring Pond, near Stuarts Draft, bottom of dried up pond, 16 Sep 1964, *R. S. Freer 2841* (GH, VPI); adjacent to Spring Pond, near Stuarts Draft, bottom of dried up pond, 23 Sep 1964, *R.S. Freer 2869* (VPI); edge of small pond near Spring Pond, 5 Aug 1967, *A.M. Harvill 17240* (FARM, NCU); Twin Ponds, near Sherando, common in drying portions of pond, elev. 1550 ft, 19 Sep 1970, *C.E. Stevens 2781* (VPI); dried up pond, open area, Twin Ponds, Big Levels Game Management Area, 19 Sep 1970, *T.F. Wieboldt 271* (WILLI); around the margins and drawdown areas of Spring Pond, elev. 1600 ft, 26 Sep 1970, *G. Ramsey, R.S. Freer, R. Bruce, et al. 18260* (WILLI); common in shallow water of open edge of Twin Ponds near Spring Pond, near Sherando, elev. 1540 ft, 16 Oct 1971, *C.E. Stevens 4772* (VPI, WILLI); Wood duck Pond, scattered in and around edges of shallow sinkhole pond 1.2 mi SE of Lipscomb, elev. 1440 ft, 2 Oct 1984, *C.E. Stevens 19078* (FARM); Campbell's Pond, 1.7 mi NW of Sherando, SW side of St. Rt. 634 1 mile N of jct. with St. Rt. 610, elev. 1470 ft, 6 Aug 1986, *G. Fenwick, s.n.* (VPI); common with *Eriocaulon septangulare* in dried muddy bed of intermittent sinkhole pond ("Twin Pond"), 2.3 mi W of Sherando, elev. 1540 ft, 22 Sep 1991, *G.P. Fleming 6126 w/ C.E. Stevens* (WILLI); Twin Ponds, located ca. 2.26 mi due W of Sherando, 8 Aug 2002, *J.F. Townsend 2869* (VPI, WILLI, Va. Div. Natural Heritage Herbarium).

Relationship to *Boltonia asteroides* var. *asteroides* and *B. caroliniana*

The gross morphology of *Boltonia montana* is nearly identical to that of *B.asteroides* var. *asteroides*, a fact which explains the use of this name in both Virginia and New Jersey for many years. *Boltonia asteroides* var. *asteroides* will be referred to as *B. asteroides* for the sake of brevity in the following discussion.

The cypselae of *Boltonia montana* are found to lack several key characteristics found in *B. asteroides*, namely: cypselae wings, cypselae trichomes, and pappus awns. Occasional plants of *B.* montana will posess cypselae with slender pappus awns that are longer than the typically low crown of scales. In this respect, such plants may have awns approaching the length seen in *B. asteroides*, but the other key features, glabrous cypselae with wings absent or vestigial, readily separate them from *B. asteroides*. Fernald (1940) described *B.asteroides* as having obovate, thick rimmed cypselae with awns wanting or up to 0.7 mm long and apparently included the plants of northwestern New Jersey in his

concept of *B. asteroides* at that time, which probably accounts for his description of awnless *B. asteroides* in Gray's Manual (Fernald 1940, 1950). In many specimens of *B. asteroides*, phyllaries are mostly sclerified and whitish on either side of the midrib and almost to the phyllary tip, becoming greenish gradually in the distal portion, and have a relatively large, resinous midrib (1/5 to 1/4 of phyllary width) which continues to the phyllary tip. In contrast *B. montana* phyllaries are only sclerified and whitened in their lower half or less, becoming green and herbaceous in the distal portion. The midrib is relatively narrow (1/10 to 1/5 of phyllary width) in the lower half and anastamoses in the distal half to produce a network of fine veins within the green portion of the phyllary. It was at first assumed that the phyllaries seen in *B. montana* were always unlike those found in *B. asteroides*, but several specimens of *B. asteroides* from the Susquehanna River in Pennsylvania have similar phyllary morphology to the former. Whether this represents past gene exchange with *B. montana* or character convergence is not known.

Due to the strong resemblance between the cypselae of *Boltonia montana* and *B. caroliniana*, the latter species was investigated to discern other morphological similarities, if present. Other than cypselae morphology, these two taxa have few character states in common.

Phyllaries of *Boltonia caroliniana* are quite dissimilar to *B. montana*, and most closely resemble *B. asteroides* in terms of their white color and relative midrib size, but are shorter and narrower than both *B. asteroides* and *B. montana*. Head size, ray corolla length, and pedicel diameter of *B. caroliniana* are smaller than in *B. asteroides* and *B. montana*, giving a delicate appearance to the inflorescence of *B. caroliniana*. In addition, typical individuals of *B. caroliniana* are profusely branched and have numerous heads. Most individuals of *B. montana* and B. *asteroides* have relatively few heads (often 1–25), although plants of both species have been noted to produce large plants with numerous heads (Karaman-Castro and Urbatsch 2006, see below). Such large reproductive outputs are seldom seen and may be a strategy to sidestep adverse meterological or edaphic conditions. Ray corollas of *B. caroliniana*, in addition to being smaller than those of *B. montana*, are white, fading to pink or lilac in age (Anderson 1987, pers. obs.), while the rays of *B. montana* are usually lilac to pinkish throughout the flowering period, though they may also be extremely pale (see Fig. 2). Most plants of *B. montana* are characterized by widely oblanceolate leaves whereas those of *B. caroliniana* are linear to narrowly oblanceolate or linear-obovate. This difference is most evident when bracteal leaves of the two species are compared.

Morphological similarity of *Boltonia montana* to *B. asteroides* and *B. caroliniana* suggest that *B. montana* may have arisen as a result of an ancient hybridization between the two species. Phylogenetic analyses of the internal and external transcribed spacers (ITS and ETS) from the nuclear ribosomal DNA suggested sister relationaship of *B. montana* and *B. caroliniana*, while only distant relationship with *B. asteroides* (Karaman-Castro et al. in prep.). Thus the treatment of the awnless and wingless specimens of *B. asteroides* as a new species, *B. montana* was supported by molecular data. However, it remains unclear whether *B. montana* is a result of an ancient hybridization between *B. caroliniana* and *B. asteroides*.

Some observations on the morphology of *Boltonia montana*

The stature of *Boltonia montana* varies from ascending to erect, with most individuals exhibiting the former condition (Fig. 1). It seems probable that this growth pattern is a response to edaphic conditions in the ponds rather than genetics. For instance, observations at "Twin Ponds" in Augusta Co., Virginia were generally of few-flowered, ascending

or erect plants from 2 to 6 dm in vertical extent (Fig. 2). This growth form is present in most populations, but was completely absent during the 2002 season at this site, where all plants were erect, 1.5–2.0 m tall, bore numerous heads, and had narrower bracteal leaves. Since this growth form was produced at the height of a multi-year drought, it seems possible that soil moisture relations were involved in mediating this morphological shift. Herbarium specimens and observations of New Jersey populations also produced the general impression of decumbent or low growth, but plants in somewhat drier microhabitats tended to be taller, more strictly erect, have more heads, and possess narrower bracteal leaves. In light of this variability, the particulars of inflorescence size and shape, head distribution, and plant stature should not be considered diagnostic of this taxon.

Adventitious roots sometimes form at nodes along the decumbent portion of stems in *Boltonia montana*. These roots are either associated strictly with the stem or may be attached to leaves similar in appearance to basal rosettes. These "offsets" are a means of vegetative propagation and are often easily detached from the plant in the fall of the year. Such rooting along the stem was encountered more often in New Jersey populations than in Virginia localities and basal offsets were produced in all populations studied. These structures are hypothesized to be the primary means of perennation in the species.

Smith and Keevin (1998) describe the adaptations for long-distance water dispersal in *Boltonia decurrens* cypselae and pointed to the evidence of such dispersal under field conditions. They found the wide, flat profile of the cypselae and wings, along with the trapping of air bubbles by cypselae trichomes, allows them to easily rest on the surface of the water. In one experiment, 20% of cypselae were still floating after 4 weeks of simulated wave action. No similar experiments have been done with *B. montana*, but cypselae morphology implies a reduced level of dispersability when compared to all other members of the genus except *B. caroliniana*. Given that nearly all *B. montana* populations are found in small, island-like wetlands within an upland matrix, these physical characteristics may have developed due to the improved survival of sedentary (wingless, awnless, hairless) cypselae. Schiffman (1997) noted wing width reductions in cypselae from island populations of *Coreopsis gigantea* (Kellogg) Hall when compared to conspecific mainland individuals. She theorized that this atrophy occurs because "dispersal-enhancing morphologies increase probabilities of being transported beyond the bounds of these narrow habitats," a classic argument applied to many specialized taxa of islands. In the case of *Boltonia montana*, the reasons for its restriction to such narrow "island-like" habitats are only speculative but it seems likely that a competitive advantage is enjoyed by the species in sinkhole ponds and enhanced dispersal structures would represent an unnecessary expenditure of energy. Occasional overland flows do provide occasional connections between neighboring sinkhole ponds in Virginia, (Christopher S. Hobson 2005, pers. comm.) and despite lacking obvious dispersal mechanisms, *B. montana* propagules could conceivably disperse to adjacent ponds during these relatively rare overflow events.

A KEY TO *BOLTONIA MONTANA* AND RELATED SPECIES

Given the morphological variability observed in *Boltonia* species, several morphological characters should always be used when identifying these taxa. Taken together, the features of phyllaries, and cypselae awns, wings, and surfaces are diagnostic of *Boltonia montana*.

The following key distinguishes *Boltonia montana* from *B. asteroides* var. *asteroides* and *B. caroliniana*, the two congeners most likely to be confused with the new taxon.

1. Cypselae with two distinct pappus awns in addition to a shorter ring of scales, the awns mostly 0.8–1.1mm long; cypselae wings obvious, mostly 0.3–0.4mm wide; lateral faces of cypselae pubescent _____ **Boltonia asteroides var. asteroides**
1. Cypselae with pappus reduced to a short ring of scales to 0.15mm long or with occasional slender awns to 0.6mm; cypselae wings lacking or up to 0.1mm wide; lateral faces of cypselae glabrous.
   2. Phyllaries 0.2–0.5mm wide, sclerified throughout or with herbaceous tip, midrib relatively prominent (1/5–1/3 phyllary width); heads 4.3–6.1mm wide, peduncles 0.25–0.5 mm in diameter; ray corollas white fading to pinkish in age; cauline and bracteal leaves narrowly oblanceolate to linear _____ **Boltonia caroliniana**
   2. Phyllaries 0.4–0.9mm wide, sclerified in lower 1/3 to 1/2 only, distal portion herbaceous, mid rib relatively narrow (1/10–1/5 phyllary width); heads 6–11.5mm wide, peduncles 0.5–1.1mm in diameter; ray corollas lilac or pinkish (-white); upper leaves oblanceolate to oblong _____ **Boltonia montana**

CONSERVATION

Isolated wetlands of the eastern United States are known for harboring a large number of rare species and for being heavily impacted by human activity (Weakley & Schafale 1994; Edwards & Weakley 2001; Comer et al. 2005). Research has focused heavily on depression wetlands of the coastal plain, but some studies have dealt with rare and disjunct species affiliated with depression wetlands of the interior (Steyermark 1963; Homoya 1983; Bartgis 1992; Fleming & Van Alstine 1999), including the rare pond endemics *Helenium virginicum* and *Scirpus ancistrochaetus*.

Ponds containing *Boltonia montana* have been the focus of conservation efforts in both Virginia and New Jersey due to the large number of globally and regionally rare plants and animals already known to occur in them. A patchwork of private and public ownership exists for these ponds, and the level of threat to these wetlands is generally high due to their small size and location within upland areas. A recent Supreme Court ruling also called into question the jurisdiction of the Clean Water Act over isolated wetlands (Comer et al. 2005), potentially relaxing protections for these natural ponds and their characteristic flora. Given their vulnerability and relative scarcity on the landscape, efforts to protect these unique wetlands should continue to be a high priority.

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A NEW SPECIES OF WATERLILY (*NYMPHAEA MINUTA*: NYMPHAEACEAE) FROM MADAGASCAR

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ABSTRACT

A new species of waterlily, **Nymphaea minuta**, is described from Madagascar. It is closely related to *N. stellata* Willd. but displays a characteristic combination of morphological characters and two growth forms in its life history. The undersurfaces of the leaves are muddy-gray to brownish-violet in color, a unique feature of the taxon. *Nymphaea minuta* in nature is a dwarf with small, submerged, cleistogamous flowers. In cultivation, it exhibits two distinct growth forms: a submerged form and an emergent form with floating leaves and larger, emergent, chasmogamous flowers.

KEY WORDS: Waterlily, *Nymphaea*, Madagascar

RESUMEN

Se describe una nueva especie de lirio de agua, **Nymphaea minuta**, de Madagascar. Está muy emparentada con *N. stellata* Willd. Pero tiene una combinación peculiar de caracteres morfológicos y dos formas de crecimiento en su ciclo vital. El envés de sus hojas es de color gris-pardo a marrón-violáceo, una característica singular del taxon. *Nymphaea minuta* en la naturaleza es una planta enana, sumergida, con flores cleistógamas. En cultivo, muestra dos formas de crecimiento diferentes: una forma sumergida y una forma emergente con hojas flotantes y flores más grandes, emergentes y casmógamas.

The senior authors' long-time interest and expertise in the cultivation, research, and identification of waterlilies has occasioned the present paper. The junior author collected seeds from Madagascar that were subsequently grown at the International Waterlily Preservation Repository in San Angelo, Texas. Upon examination of these garden-grown plants, it became apparent that the material concerned represented an undescribed taxon, the description of which follows.

Nymphaea minuta K. Landon, R.A. Edwards & P.I. Nozaic, sp. nov. (**Figs. 1–4**). TYPE: MADAGASCAR: near village of Tampolo, Coastal Forest in shaded rain pools (ca. 49°... 26' E, 17° ... 15' S), 1 Jul 1999, *P.I. Nozaic s.n.* (HOLOTYPE: TEX).

Nymphaeae stellata Willd. Verdcourt similis sed differt floribus diurnalibis roseis vel albis in caulibus submersis et/vel emergentibus portatis et paginis foliorum emergentium supra viridibus infra limoso-canis vel dilute brunneolo-violaceis.

Plants rhizomatous growing horizontally, of two distinct forms: submerged and emersed. **Submerged** (underwater) **form:** leaves very thin, flaccid, ovate, the margins entire and wavy, surfaces glabrous, pustulose to wrinkled, bright green above, the veins distinct, lower surfaces medium-green with a bronze to reddish cast, the veins bright green, obvious and distinct, having 5 primary veins on each side of the midvein, the surface glabrous, pustulose to wrinkled, the sinus slightly open with some overlap near attachment to peti-

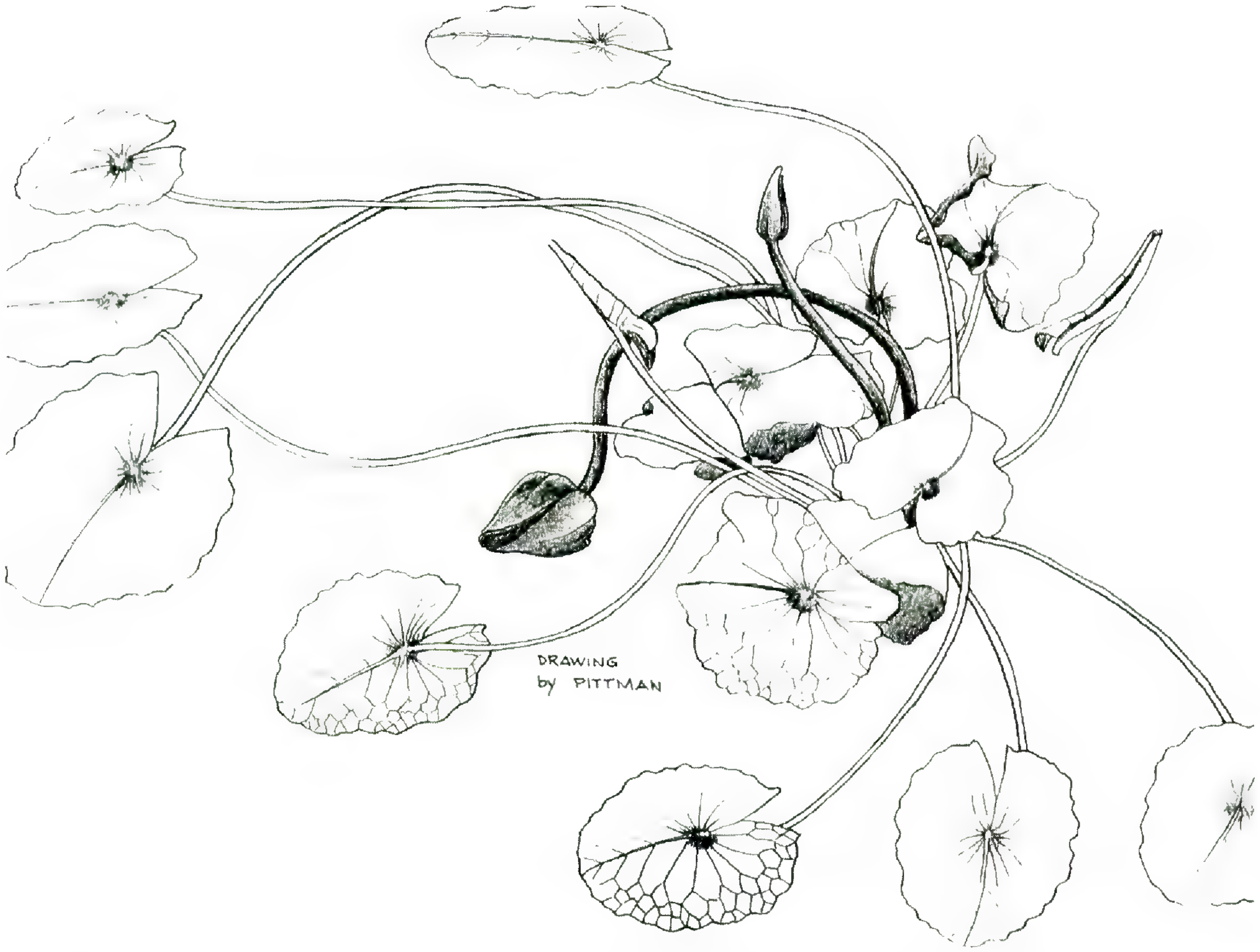


Fig. 1. *Nymphaea minuta*. Plant with submerged and floating leaves (from holotype).

ole; blades mostly 10 cm × 14 cm, the petioles usually less in length than the blade, keeping habit of plant compact and rosette-like in shape; petioles 2–3 mm wide, olive green, glabrous. Flowers produced on submerged plants rarely reaching surface, cleistogamous, rarely opening underwater; base of cleistogamous bud 0.5–2.0 cm wide, 1.5–2.0 cm long; ripe fruit to 3 cm × 3 cm, petioles slightly curving down as fruit matures, fruit ruptures to release seed, seeds brown, oval, smooth, ca. 0.5 mm wide, at release enclosed by aril. **Emergent** (above water) **form**: leaves round, 7–12 cm wide, margins entire to slightly sinuate near sinus, sinus open with 10° to 30° angle, the surface medium-green with no other pigmentation or marking at any stage of development, lower surface pale violet with brown tones, muddy-gray appearance, bright green veins distinctive, petioles olive-green, maximum length observed 24 cm, all surfaces free of hairs or scales, overall growth pattern a circle of ca. 60 cm wide. Flowers small, 2.5–4.0 cm wide; sepals 3 to 4, somewhat longer than the petals, tips blunt-pointed, twice the width of petals at the base, sepal olive green changing to magenta at base with faint lighter stripes on outside, 7 to 9 veins, pale pink to white on inside, with faint greenish stripes. Petals 6 or 7, pale pink to white, 1.5–2.0 cm long, 0.5 cm at base, tapering to a blunt-pointed tip, with 3 main veins and 2 smaller veins on the outer edges. Stamens 8–32, shorter than petals, yellow with appendages following petal color. Anthers comprising most of the length, ripe pollen released on the 1st day, self-pollinating but also receptive to pollination by other waterlilies in the subgenus *Brachyceras*. Carpels 5 to 15, carpellary appendage a hook-like extension on outside wall of carpel, 2–3 mm long. Flowers open near noon and close by late afternoon,

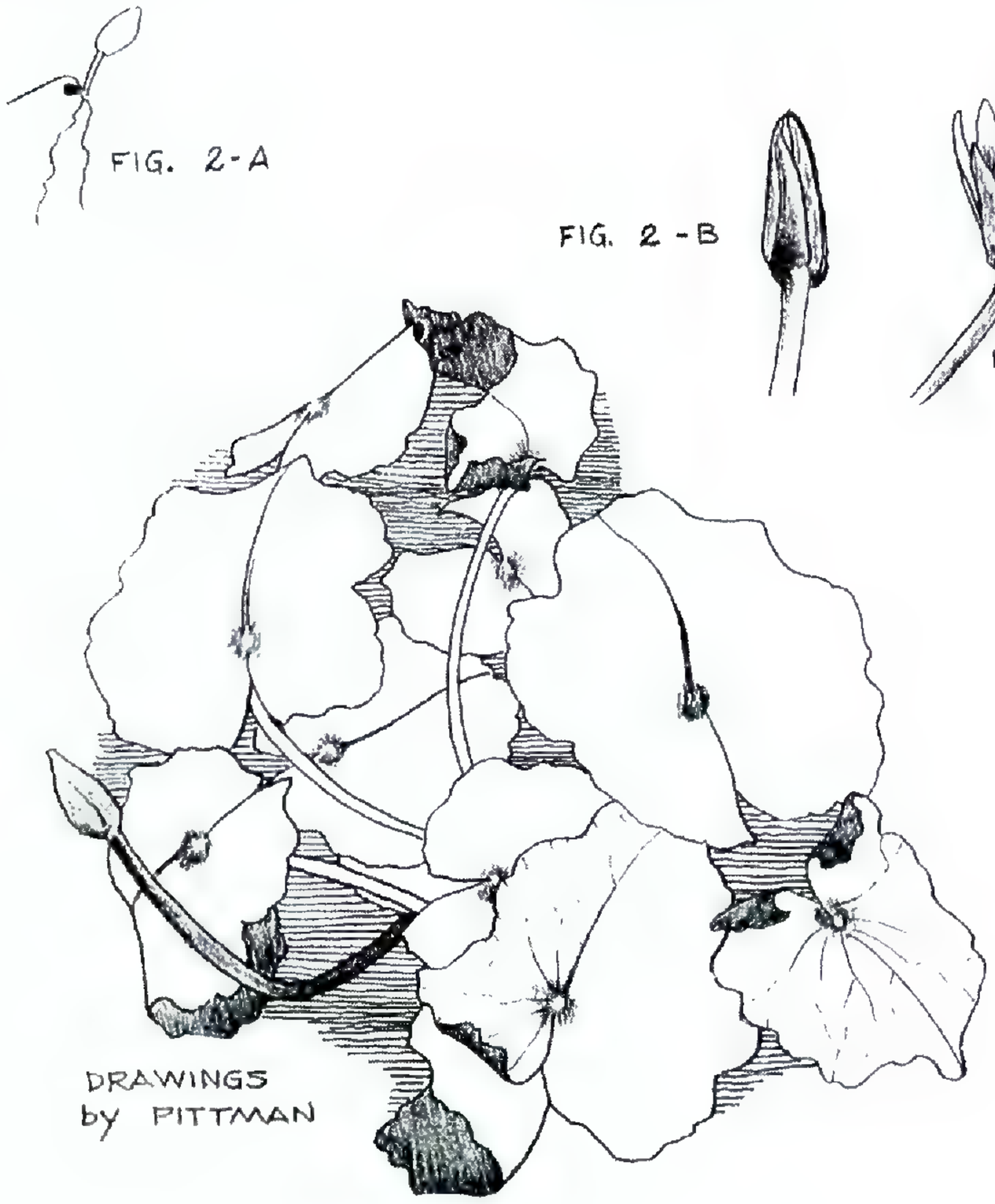


FIG. 2. ***Nymphaea minuta*****. A.** Seedling. **B.** Bud. **C.** Submerged and or aerial flower. **D.** Aerial flower. **E.** Fruit.

submerge on third day, open to ca. 45° on first day, and slightly more on 2nd day, often do not open on 3rd day, first day flowers usually produce stigmatic fluid, peduncles curve down into water as fruit matures. Fruit orbicular, ca. 3 cm × 3 cm, rupturing to release seeds; seeds brown, smooth, oval, ca. 0.5 mm wide, enclosed by aril at release.

Distribution and Ecology.—This species is known in Madagascar only from the type locality, where it grows in jungle pools along slow-moving streams. The new species is adaptable to growing conditions other than those encountered at the type location and easily cultivated, especially in low-light environments.

Etymology.—The type plants discovered in Madagascar were all dwarf. Under typical waterlily cultivation, all plants grown remained dwarf. Only under intensive atypical cultivation regimes have larger plants been produced. This species is by far the smallest known species of *Nymphaea*. The epithet 'minuta' was proposed by the author who discovered this species. After five years of cultivation and multiple generations for consideration, all authors believe '*minuta*' to be accurate and appropriate.

Life history of *Nymphaea minuta*

Nymphaea minuta in nature is a dwarf with a submerged habit, including small, cleistogamous, submerged flowers. These flowers rarely reach the water surface and apparently are self-fertilized without the sepals opening or exposing the petals. Various species from all subgenera of *Nymphaea* are self-pollinating, but only *N. minuta* has been documented to do this underwater. Plants of *N. minuta* in cultivation display both submerged and



FIG. 3. Top, submerged plants under artificial light in an aquarium, not submerged bud on center plant. Bottom, submerged plant grown in pond under nature conditions in a tropical climate.



FIG. 4. Clockwise from top, mature *Nymphaea minuta*, emersed form with flower, ca. 60 cm wide; close up of flower showing stigmatic disk, carpellary styles and appendages on stamen; submerged flower fully open.

emergent growth forms, the flowers are chasmogamous and vary from floating on the water to rising above the surface. Floral morphology and color remain constant in all growth forms. In response to changing environmental conditions, an individual plant can switch from one form to the other. During these transitions, intermediate phases with both floating and submerged leaves are produced, along with both emergent and submerged flowers (Fig. 2a, 2b). Light intensity and duration appear to be the controlling factor in these transitions.

In temperate latitudes, mature plants of *Nymphaea minuta* exposed to full sun will develop the emergent phase throughout the summer but revert to the submerged phase as the daylight lessens in length and intensity. The same plant often reverts back to the emergent phase the following summer.

Almost all cultivated specimens have been dwarf. However, under cultivation with fertilization and optimum conditions of light and climate, plants have been produced roughly four times larger (including flowers and all vegetative parts of the plants) than the dwarf plants first discovered. Seeds [of cleistogamous and chasmogamous flowers] remain the same size, although the number of seeds produced from the larger flowers and resulting larger fruits, increases proportionally to the rest of the plant. The number of carpels and stamen also increase at the same ratio as the size increase of vegetative parts.

Seedlings produced in full sun in late spring through mid summer will immediately grow into an emergent plant, with floating leaves and flowers at or above the water surface, typical of brachyceras tropicals. Seeds germinated in the late summer or fall will often grow in the submerged form until the following summer or until artificial light of enough intensity and duration are provided, causing the plant to transform into the emergent form. Seedlings grown in shade remain in the submerged phase but continue to grow and produce flowers and fertile fruits.

In chasmogamous flowers, stigmatic fluid is usually produced on the first day of anthesis, and ripe pollen is released. As the fruit ripens, the peduncles bend downward and fruits mature beneath the water surface.

As the plants mature, a perennial rhizome is produced. Dormant tubers have been produced in cultivation and would be expected to occur in the wild populations in ephemeral conditions.

Relationship of *Nymphaea minuta* to other species

Characters of the flowers place the new species in *Nymphaea* subgenus *Brachyceras*. The carpels are free at the sides with separate walls for each ovary. Carpellary styles are present as a small hook-like extension at the back of each carpel. The stamens have distinct appendages beyond the anthers.

Nymphaea minuta at a glance superficially more closely resembles *Nymphaea stellata* Willd. (not *N. nouchali* Burm. f., a different species, in our opinion) of tropical Asia than any other known species of waterlily. Both species display a coarsely dentate margin on floating leaves. Flowers display very low petal numbers in both species. The type habitat for *N. minuta* would also support *N. stellata* although in a stunted form. Such plants would in fact more closely mimic the dwarf nature of *N. minuta* rather than a typically proportioned *N. stellata*.

Upon closer inspection several differences between the two species would become apparent. *Nymphaea minuta* has no contrasting pigmentation upon the leaves in either

form. *Nymphaea stellata* often display slight mottling or flecks of purple pigmentation on floating leaves as they mature. The lower surface of the leaves of both species exhibit distinct and different venation and pigmentation patterns. Like most *Nymphaea* species, *N. stellata* produces submerged leaves as seedlings and emerging from dormancy, but they are diminutive, quickly deteriorate and do not represent a submerged growth form. *Nymphaea minuta* produces substantial and persistent submerged foliage, flowers and fruits, completing a full life cycle completely submerged.

Nymphaea minuta apparently will hybridize with other species and cultivars of subgenus *Brachyceras*. With *N. minuta* as pollen donor, cross-pollination was attempted on *N. micrantha* Guill. & Perr. and *N. colorata* Peter. and seed development proceeded in normal fashion. Similar results were obtained using three additional cultivars as seed parents. *Nymphaea minuta* was also used as the seed parent with crosses to hybrids with distinctive features, such as pigmentation on leaves. Further tests must be performed to see if cross-pollination actually occurred (vs. asexual seed development), but both senior authors have progeny from crosses displaying obvious hybridization. Crosses within the subgenus *Brachyceras*, with resulting progeny displaying obvious characteristics, such a pigmentation on the leaves similar to the pollen parent, provides further evidence this species should be placed within the subgenus *Brachyceras*.

Dimorphism in growth form is a rare feature in the genus *Nymphaea*. No published material exists discussing this feature with any other known subgenus of *Nymphaea*. At the International Waterlily Preservation Repository, we have another taxon in the subgenus *Brachyceras* that appears to exhibit some degree of persistent submerged growth, however, the research is incomplete.

ACKNOWLEDGMENTS

We are grateful to Guy Nesom for the Latin diagnosis and for a detailed review of the manuscript and to B.L. Turner for his encouragement and help with this project. We also thank Ed Schneider for a thorough review of the paper. Drawings for the new species were kindly provided by Katherine Pittman.

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Book Review

Donald G. Crosby. 2004. **The Poisoned Weed, Plants Toxic to Skin** (ISBN 0-19-515548-3, hbk.). Oxford University Press. (**Orders:** Oxford University Press, 2001 Evans Road, Cary, NC 27513, U.S.A., 800-451-7556, 919-677-1303 fax, www.oup.com). $59.95, 214 pp., figures, graphs, 24 color figures, 6 1/2" × 9 1/2".

Dermatoxic plants are all around us. The book entitled helps readers learn much more about the plants that cause itchiness, rashes and other very painful symptoms. This book gives a detailed background with comprehensive, technical information on the chemicals involved in causing dermatoxic reactions.

The book consists of ten chapters. The first gives a background history of a variety of plants that cause reactions such as allergic contact dermatitis (ACD) in humans. Much of this history centers on the naming, history and perceived causes of the ACD reaction from poison ivy and its relatives. The second chapter focuses on the taxonomy, habitat and distribution of the poison ivies and their relatives. The third chapter discusses other plants that can cause ACD in humans. Plants covered by the "other allergens" include wild species such as *Metopium toxiferum* (poisonwood), Quinone-containing plants such as the primroses (*Primula* sp.), trees or exotic hardwoods such rosewood (*Dalbergia* sp.), lactone-containing species such as *Laurus nobilis* (Grecian laurel), weeds, food plants and others.

Chapter four discusses phytotoxic plants from the Rutaceae family, Apiaceae family, and Moraceae family along with irritant plants from the Euphorbiaceae, Brassicaceae, Alliaceae, and Urticaceae families. Chapter five is a chapter detailing chemical and physical properties of the allergens related to urushiol. This information includes identification and analysis, oxidation, photo- and bio-degradation, reactions with proteins and more. Chapter six includes details on the physical and chemical properties of allergens such as quinines, lactones, acetylenic alcohols, essential oils, lichen substances, and rubber latex. Chapter seven discusses the physical and chemical properties of phytotoxic and irritant (non-allergenic) substances, including Furocoumarins, Hypericins, Irritant esters, organosulfur compounds, irritant amines and amides, and calcium oxalates. Chapters eight and nine explain forms of exposure to various ACD substances and their adverse effects.

Chapter ten includes methodologies to prevent exposure to ACD substances as well as discussion on treatment options. The chapters are followed by multiple appendices, containing chemical structures and physical properties for various substances discussed in the text and some key references. Indices are separated into plant names, chemicals under common names and a general index.

The Poisoned Weed: Plants Toxic to Skin is a very informative and timely book. Primarily designed for professionals in the biochemical, chemical, and medicinal fields, it looks to be the new authority on dermatoxic plants and substances which cause allergic contact dermatitis.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

TWO NEW COMBINATIONS IN *PEYRITSCHIA* (POACEAE: POOIDEAE: AVENINAE)

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ABSTRACT

Trisetum howellii Hitchc., an endemic species from the Galapagos Islands, Ecuador, and *Trisetum pinetorum* Swallen, an endemic species from Guatemala, are transferred into **Peyritschia** [**P. howellii** (Hitchc.) Finot & P.M. Peterson; **P. pinetorum** (Swallen) Finot & P.M. Peterson]. *Peyritschia* is now circumscribed to include seven species with new areas of distribution documented in South America. A key distinguishing the species and table comparing the salient morphological features of all species within *Peyritschia* are provided.

RESUMEN

Trisetum howellii Hitchc., especie endémica de las Islas Galápagos, Ecuador, y *Trisetum pinetorum* Swallen, especie endémica de Guatemala se transfieren a **Peyritschia** [**P. howellii** (Hitchc.) Finot & P.M. Peterson; **P. pinetorum** (Swallen) Finot & P.M. Peterson]. *Peyritschia*, así circunscrita, incluye siete especies con nuevas áreas de distribución documentadas en Sudamérica. Se proporciona una clave para distinguir las especies y un cuadro donde se comparan las características morfológicas sobresalientes de todas las especies de *Peyritschia*.

The genus *Peyritschia* was described by Fournier (1886) and originally included only one species, *P. koelerioides* (Peyr.) E. Fourn., based on *Aira koelerioides* Peyr., from southern México and Guatemala (Finot et al. 2004). A second species from México, *Deschampsia pringlei* Scribn., was transferred to *Peyritschia* by S.D. Koch in 1979 [= *P. pringlei* (Scribn.) S.D. Koch], and is also known from Guatemala, Costa Rica, Venezuela, and Ecuador (Hernández-Torres & Koch 1988; Pohl & Davidse 1994; Finot et al. 2004). This small genus (*Peyritschia*) was later included within *Trisetum* by Hernández-Torres and Koch (1987). When placed in *Trisetum*, *P. koelerioides* and *P. pringlei* are named: *Trisetum altijugum* (E. Fourn.) Scribn. and *T. kochianum* Hern.-Torres., respectively.

Peyritschia has isomorphic to sub-isomorphic, linear, 1–3-nerved glumes; bilobed lemmas that are awned near the base or the middle of the back or the awn reduced to a subapical mucro; paleas that are tightly enclosed by the margins of the lemma; linear lodicules; and an androecium composed of two stamens. In contrast, *Trisetum* has heteromorphic, ovate-lanceolate or oblanceolate, 1–5-nerved glumes [first glume 1(–3)-nerved, second glume 3(–5)-nerved]; lemmas with 2 to 4 short setae at the apex due to the prolongation of the nerves and a dorsal awn born on the upper third of the lemma, rarely located near the middle of the back; paleas that are free from the margins of the lemma; lodicules with 2- or 3-lobed apices; and an androecium with three stamens (Finot et al.

2004, 2005a, 2005b). *Peyritschia* includes perennial herbs with flat leaf blades, membranous ligules, narrow to contracted-spiciform or lax and somewhat open panicles, 2(–3)-flowered spikelets, rachillas disarticulating above the glumes and between the florets, glabrous ovaries, and caryopses with liquid endosperm. Previous studies showed that the micromorphology of the lemmatal epidermis has good characters to distinguish *Trisetum* from *Peyritschia*. Most species of *Peyritschia* lack prickles hairs (present in all species of *Trisetum*), although, if present, they are restricted to the keel or the apex of the lemma in *P. deyeuxioides* and *P. pinetorum*. All species of *Peyritschia* have bordered hooks alternating with epidermal long cells (hooks not bordered, nor alternating with long cells in *Trisetum*) and lack macrohairs (macrohairs are present in some species of *Trisetum*) [Finot et al. 2006]. These characteristics along with the salient features of the spikelet, were considered important for resurrecting the genus by Finot (2003a) who transferred three additional species into *Peyritschia*: *P. conferta* (Pilg.) Finot (=*Trisetum confertum* Pilg.) from Bolivia, Ecuador and Venezuela; *P. deyeuxioides* (Kunth) Finot (=*T. deyeuxioides* Kunth) widely distributed in México, and extending into Central and South America (Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panamá and Venezuela); and *P. humilis* (Louis-Marie) Finot (=*T. humile* Louis-Marie), an endemic in México (Finot et al. 2004).

Trisetum confertum was originally described from an Ecuadorian specimen (Crescit in Prov. Imbabura, ad Loma de Canaballa et locis vicinis; alt. 2100–2300 m; *A. Stübel 152*; holotype, B; isotypes, US-81771 ex B!, CONC fragm. and photo ex B!). Hitchcock (1927) cited this species as occurring in Cochabamba, Bolivia. Later, Valencia (1941) moved the species to *Deschampsia* [*D. conferta* (Pilg.) Valencia]. However, Parodi (1949) and Chiapella (2000) excluded it from *Deschampsia*.

More recently, two species, *Trisetum deyeuxioides* and *T. humilis*, were transferred in *Peyritschia*, based on spikelet and floret characteristics (Finot 2003a; Finot et al. 2004).

Three of the five currently recognized species of *Peyritschia* are found in Guatemala: *P. koelerioides* (the type species of the genus) also extends into southern México; *P. pringlei* also present in México, Costa Rica, Venezuela, and Ecuador; and *P. deyeuxioides* ranging from southern México to Ecuador (Pohl & Davidse 1994; Espejo-Serna et al. 2000; Finot 2003a; Finot et al. 2004).

The following seven species of *Trisetum* have been mentioned as occurring in Guatemala: *T. angustum* Swallen from San Marcos near Volcán Tajumulco, also extending into southern México; *T. pinetorum* Swallen here transferred to *Peyritschia*, from Quetzaltenango near Volcán Santo Tomás, and now known from México; *T. viride* (Kunth) Kunth (syn. *T. altum* Swallen) from El Progreso also widespread in México; *T. irazuense* (Kuntze) Hitchc. from Huehuetenango near Tunimá, mentioned for the first time by Finot et al. (2004), also from Costa Rica, Honduras, Panama, Colombia, Venezuela, Ecuador, and Peru; *T. rosei* Merr. from Huehuetenango from near Volcán Santa María, also extending into México; *T. pringlei* (Scribn. ex Beal) Hitchc. from Huehuetenango and Totonicapán, also found in México, Costa Rica, and Panama; and *T. spicatum* (L.) K. Richt. with a wide distribution in the Americas (Swallen 1955; Pohl 1980; McVaugh 1983; Hernández-Torres 1988; Pohl & Davidse 1994; Finot 2003b; Finot et al. 2004, 2005a, 2005b).

In Ecuador, the following four species of *Trisetum* have been reported: *T. andinum* Benth., endemic to Ecuador; *T. spicatum* and *T. oreophilum* Louis-Marie var. *oreophilum* ranging from Ecuador to Perú and Bolivia (Finot et al. 2005b); and *T. howellii* here trans-

ferred to *Peyritschia*. Species of *Peyritschia* found in Ecuador are: *P. deyeuxioides* and *P. pringlei* (Finot 2003a).

Preliminary phylogenetic analyses using morphological characters within *Trisetum* s.l. (including *Trisetum* s.s., *Peyritschia*, and *Sphenopholis*) [Finot 2004], depicts a well-supported clad (bootstrap of 95 %) that includes *Peyritschia koelerioides*, *P. pringlei*, *P. deyeuxioides*, *P. conferta*, and *T. howellii* Hitchc. This clade is supported by three synapomorphies: terete lemmas in lateral view, two stamens, and ornamentation of the lemma.

In this paper we make two new combinations, *Peyritschia pinetorum* (Swallen) Finot & P.M. Peterson, from Volcáns Atitlán and Santo Tomás, Guatemala, and *P. howellii* (Hitchc.) Finot & P.M. Peterson, from Galápagos, Ecuador. In addition, we include a key to distinguish all seven species, a table comparing their salient morphological features, and a new illustration, description, and SEM photo of the lemmatal surface of *P. pinetorum*.

Peyritschia howellii (Hitchc.) Finot & P.M. Peterson, comb. nov. (Table 1). *Trisetum howellii* Hitchc., Proc. Calif. Acad. Sci., ser. 4, 21(24):296. 1935. TYPE: ECUADOR. GALÁPAGOS ISLANDS: Indefatigable Island, Mt. Crocker, 9 May 1932, *J.T. Howell 9208* (HOLOTYPE: CAS-211262!; ISOTYPE: US-1611545!).

Perennials; culms 35–60 cm tall, weak; internodes glabrous, 5–6 nodes per culm, nodes glabrous. Leaf sheaths shorter than the internodes, glabrous, striate; ligules 0.5–1.5(–2) mm long, apex obtuse, not ciliate, sometimes denticulate, glabrous; blades 8–15 cm × 2 mm, flat, glabrous, smooth, margins sometimes scabrous. Panicles 8–18 cm long, (0.5–)10–20 mm wide, contracted, narrow, lax, somewhat open, exserted or sub-included in the upper sheath; rachis and pedicels glabrous; spikelets 4.5–5.5 mm long, (1-)3-flowered; rachillas 1.5 mm long, copiously pilose, the hairs ca. 1.5 mm long, as long as the rachilla; glumes almost covering the florets, isomorphic, linear to linear-lanceolate, narrow, somewhat scabrous on the keel, the margins hyaline, apex acute, purplish; first glumes 4.3–4.7 × 0.3 mm, 1-nerved; second glumes 4.7–5.5 × 0.4 mm, 1–3-nerved; first lemmas 4–4.5 × 0.5 mm, linear-cylindrical to linear-lanceolate, glabrous, smooth, or scaberulous only towards the apex, purple towards the apex, rounded on the back, the margins enclosing the palea, 5-nerved, awned, the awn 5.5–7 mm long, twisted, geniculate, somewhat scabrous, borne on the upper third of the lemma, at 1–1.5 mm below the apex, the apex bidentate, toothed, acute with the intermediate and marginal nerves conspicuous towards the apex; callus obtuse, with stiff hairs, the hairs 0.5 mm long; paleas 3–4.3 mm long, shorter than the lemmas, 2-nerved, the nerves scabrous towards the apex, apex acute, hyaline; ovary glabrous; lodicules 0.6 mm long, linear, entire; stamens 2, anthers about 0.8 mm long. Caryopses 2 mm long, glabrous; endosperm liquid.

Phenology.—Flowering from September to January. Matures fruits are found from February to March.

Distribution and habitat.—*Peyritschia howellii* is an endemic species from Ecuador. Most of the studied collections come from Isla Santa Cruz (Indefatigable), Galapagos, growing between 480–1000 m; *Jeppesen 76* (AAU) is the first collection of the species made from Isla San Cristóbal (Chatham).

Comments.—*Peyritschia howellii* was included by Valencia et al. (2000) in the Red Book of the endemic plants of Ecuador (as *Trisetum howellii*).

Additional specimens examined. **ECUADOR. Galápagos Islands:** Isla Santa Cruz, in area that includes W slope of Media Luna, E slope of Cerro de los Caminos and flat plain between, 4 Sep 1975, *D.A. & D.B. Clark 447* (AAU); Puntudo, 17 Mar 1977, *A. & H. Adsersen 1413* (QCA); ca. 600 m, 8 Nov 1966, *U. & I. Eliasson 557* (S); sur de Mt. Crocker, 710 m, 17 Oct 1966, *U. & I. Eliasson 284* (S); Norte de Bella Vista, 480 m, 19 Oct 1966, *U. & I. Eliasson 356* (S); no date, *Fagerlind & Wibon 2957* (S); no date, *Fagerlind & Wibon 3320* (S); highest mountain top, 860 m, 23 May

TABLE 1. Salient morphological characteristics to distinguish among the seven species of *Peyritschia*.

	P. conferta	P. deyeuxioides	P. howellii	P. humilis	P. pinetorum	P. koelerioides	P. pringlei
Panicle shape	narrow, contracted	lax, somewhat open and nodding	narrow, somewhat open	narrow, contracted	narrow, contracted	spiciform somewhat open	narrow,
Number of florets per spikelet	2	2 or 3	(1–)3	2	2	2	2 or 3
Spikelet, length (mm)	5.0–55	4.5–8.0	4.5–5.5	4	5–7	3–5	4–5.5
Glumes, shape	oval-lanceolate	linear	linear to linear-lanceolate	lanceolate	lanceolate to ovate-lanceolate	lanceolate to ovate-lanceolate	lanceolate
Glumes, size verses spikelet	longer	equal, shorter or longer	equal	longer	slightly shorter	longer	as long as the florets or longer
Glumes, length (mm)	5.2–5.5	(3.5–)4–5.5 (–8)	4.3–5.5	4	4.5–6	3–5	4–5.3
Lemma, length (mm) (lower floret)	3.5–5.0	4–6	4–4.5	3–3.5	5–6	2.5–4	3–4.3
Lemma, apex	bilobed, lobes obtuse	entire or bilobed to b'dentate	bidentate, toothed, acute	bilobed, lobes obtuse	bifid, toothed, acute	bilobed, lobes obtuse	bilobed, lobes obtuse
Rachilla, indument	sparsely pilose	copiously pilose	copiously pilose	sparsely pilose	copiously pilose pubescent	glabrous to sparsely	sparsely pilose
Awn, position	basal	median	upper third	middle or lower third	median	apical if present (as a short mucro)	basal
Awn, shape	geniculate, twisted	geniculate, twisted	geniculate, twisted	geniculate, twisted	geniculate, twisted	straight or absent	geniculate, twisted
Awn, length (mm)	6–7	4.5–8(–12)	5.5–7	4-5	7–12	0–1	4.5–7
Callus indument	short pubescent	short pubescent	short pilose	sparsely pilose	pilose	glabrous to short pubescent	short pubescent

1959, *Harling 5764* (S); 1850 ft, 27 Jul 1974, *van der Werff 1330* (S); Mt. Crocker, 840 m, 18 Feb 1967, *Wiggins & Porter 652* (S); fern-sedge zone along trail to Mt. Crocker, 500 m, 6 Feb 1964, *Wiggins 18577* (S); Isla San Cristóbal, El Junco, 650 m, 28 Feb 1976, *Jeppesen 76* (AAU).

Peyritschia pinetorum (Swallen) Finot & P.M. Peterson, comb. nov. (**Fig. 1**, Table 1). *Trisetum pinetorum* Swallen, Phytologia 4:424. 1953. TYPE: GUATEMALA. QUEZALTENANGO: Volcan Santo Tomás, on pine-*Abies*-clad slope, 2500–3700 m, 22 Jan 1940, *J.A. Steyermark 34824* (HOLOTYPE: F-1048257!; ISOTYPES: MO fragm. ex F!, US-2240525 ex F!, US-2236478 fragm. ex F!).

Perennials; culms 33–70 cm tall, weak, internodes glabrous, 3–4 nodes per culm, nodes glabrous. Leaf sheaths shorter than the internodes, glabrous, striate; ligules 1.5–3 mm long, truncate, dentate-laciniate, glabrous; blades 5–10 cm long, 1–1.5(–2) mm wide, flat, glabrous above and below. Panicles 5–15 cm long, 5–10 mm wide, contracted, narrow, somewhat lax, somewhat interrupted, exserted or sub-included in the upper leaf sheath; rachis glabrous; pedicels scabrous or glabrous. Spikelets 5–7 mm long, 2-flowered; rachillas ca. 1 mm long, copiously pilose, the hairs about 1–2 mm long; glumes slightly shorter than the florets, sub-isomorphic, lanceolate to ovate-lanceolate, the keel smooth to slightly scabrous towards the apex, apex acute; first glumes 4.5–6 × 0.7–0.8 mm, a little shorter and narrower than the second glumes, 1-nerved; second glumes 5–6 × 0.7–0.8 mm, 1-or 3-nerved; first lemma about 5–6 mm long, lemmas glabrous, awned, rounded on the back with involute margins on the lower 1/2 enclosing the palea, the awn 7–12 mm long, twisted, geniculate, and inserted on the median portion of the back, the apex deeply bifid with acute teeth, each tooth with two short awns derived from the prolongation of the marginal and intermediate nerves; callus obtuse, with short hairs, the hairs ca. 1 mm long; paleas about 3.5–4 mm long, shorter than the lemmas, 2-nerved, the nerves scabrous towards the apex, apex acute; lodicules about 0.5 mm long, linear, sometimes with a little lateral lobe near the median portion, the apex subacute; stamens 2, anthers 0.9–1.5 mm long; ovary glabrous. Caryopses not seen.

Lemma micromorphology. Long cells rectangular, 3–12 times longer than wide; anticlinal walls parallel and highly undulate, the undulations U- or V-shaped; periclinal walls flat; silica cells about 10 µm in diameter, short, elliptical; stomata absent; prickle hairs about 45 µm long, ovate-elliptical, restricted to the keel and with a short apical barb; long cells about 10–12.5 µm in diameter, alternating with bordered hooks; macrohairs absent (Fig. 2.).

Phenology.—Flowering in January.

Distribution and habitat.—Known only from southwesterm Guatemala in Departamentos Quetzaltenango and Sololá. Apparently, *P. pinetorum* is restricted to volcanic soils since the only two localities are from higher elevations (2500–3700 m) on slopes of Volcán Atitlán and Santo Tomás.

Comments.—This new combination can be distinguished from all other known species of *Peyritschia* by having lemma apices that are deeply bifid, and these apices end in four hyaline setae derived from the apical extension of the marginal and intermediate nerves (Table 1). The presence of these setae suggests that *P. pinetorum*, in a phylogentic sense, lies very near *Trisetum*. Nevertheless, because of the shape of the lodicules (entire in *Peyritschia* and bilobed or toothed in *Trisetum*), the lemmas rounded on the back (versus keeled in *Trisetum*), the awn inserted on the median portion of the lemma [inserted on upper 1/3 in *Trisetum* except in *Trisetum* subgen. *Deschampsioideum* (Louis-Marie) Finot], paleas that are tightly enclosed by the margins of the lemma (gaping in *Trisetum*



FIG. 1. *Peyritschia pinetorum* **A.** Habit. **B.** Sheath, ligule, and portion of the blade. **C.** Spikelet. **D.** First floret. **E.** Palea, dorsal view. **F.** Palea, ventral view. **G.** Rachilla. **H.** Lodicules. **I.** Ovary/developing caryopsis, dorsal view. **J.** Ovary/developing caryopsis, ventral view.

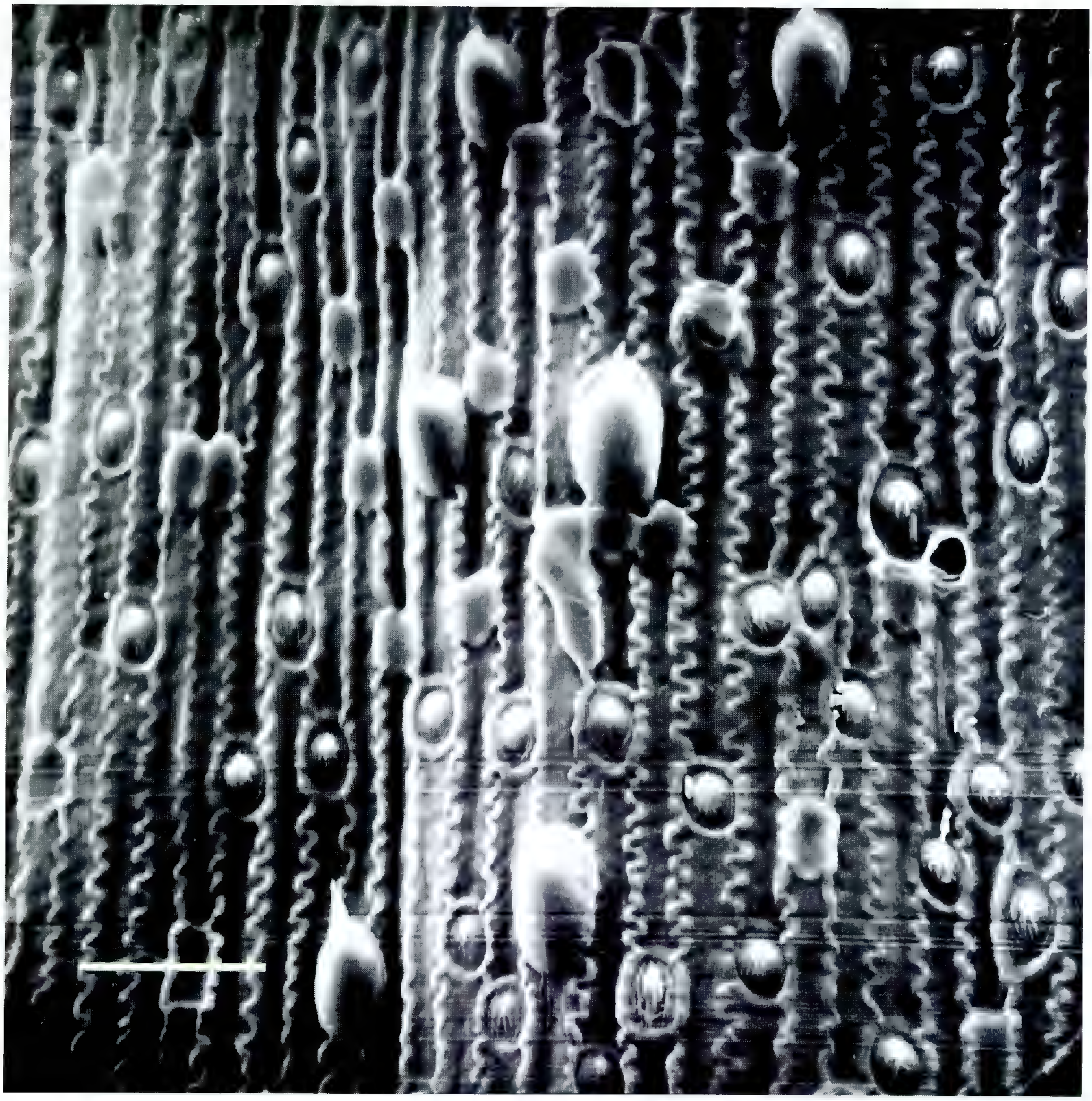


FIG. 2. SEM photograph of the lemma epidermis (×400) of *Peyritschia pinetorum* (*Steyermark 34824*) showing bordered hooks alternating with long cells. Scale bar = 55µm.

and not tightly enclosed by the margins), an androecium with two stamens (3 stamens in *Trisetum*), and lemmatal epidermis with bordered hooks alternating with long cells (verses epidermis without bordered hooks, the hooks not alternating with long cells in *Trisetum*) [Fig. 2.], we place the new species in the genus *Peyritschia*.

Additional specimen examined. **GUATEMALA. Sololá:** Volcán Atitlán, crater (14°35'58.8"N-91°11'9.6"W), 11650 ft (3540 m), 23 Jan 1907, *W.A. Kellerman s.n.* (US-2181368).

KEY TO THE SPECIES OF *PEYRITSCHIA*

1. Lemma without a dorsal awn, apex muticous or with a subapical mucro _____ **P. koelerioides**
1. Lemma with a dorsal awn, the awn geniculate and extended beyond the glumes.
   2. Rachilla copiously pilose, the hairs 1–3 mm long; awn borne on the middle or the upper third of the back of the lemma.
      3. Lemma with the apex deeply bifid; panicles 5–15 cm long, contracted, narrow _____ **P. pinetorum**

3. Lemma with the apex entire or shortly bidentate or bilobate; panicles 8–35 cm long, lax, somewhat open.
   4. Rachillas with hairs 2–3 mm long; glumes linear 5.2–5.5 mm long; awn borne on the middle portion of the lemma _____ **P. deyeuxioides**
   4. Rachillas with hairs about 1.5 mm long; glumes linear to linear-lanceolate 4.3–5.5 mm long; awn borne on the upper third of the lemma _____ **P. howellii**
2. Rachilla pubescent, the hairs 0.2–0.8 mm long; awn borne near the base of the lemma.
   5. Culms 5–12 cm tall; leaf blades 2.3–3.5 cm long; panicles about 2.5 cm long, 0.5 cm wide _____ **P. humilis**
   5. Culms 20–200 cm tall; leaf blades 5–15 cm long; panicles 5–20 cm long, 1–4(–4) cm wide.
      6. Spikelets 2- or 3-flowered, 4–5.5 mm long; glumes 4–5.3 mm long; lemma 3–4.3 mm long _____ **P. pringlei**
      6. Spikelets 2-flowered, 5–5.5 mm long; glumes 5.2–5.5 mm long; lemma 3.5–5 mm long _____ **P. conferta**

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Book Review

Matt White. 2006. **Prairie Time: A Blackland Portrait.** (ISBN 1-58544-501-0, hbk.). Texas A&M University Press, 4354 TAMU, College Station, TX 77843-4354, U.S.A. (**Orders:** 979-458-3982, 979-847-8752 fax; http://www.tamu.edu/upress/). $19.95, 272 pp., b/w figures, 1 map, index, 5 1/2" × 8 1/2".

Texas-prairie enthusiasts will relish author Matt White's new memoir of the Blackland Prairie called *Prairie Time: A Blackland Portrait*. His new book intertwines the author's interests in the Blackland Prairie with personal touches of family, natura, and land histories, with prairie ecology—all with the background of his sentimental memories of the Blackland Prairie region.

The book is a collection of Matt White's experiences in exploring prairie remnants; among these are his interactions with land stewards and also stories of unfortunate losses of prairie remnants to various causes. Throughout the book there is information on animals that have inhabited the prairie, such as the prairie chicken and wild turkeys, as well as information on the importance of prairie as wildlife habitat. Prairie ecology is dotted through the text as well. For example, you'll find information on the importance of fire to the prairie system, the formation and characteristics of prairie soils, flora indicative of prairie areas, and flora invasive to the prairie. A discussion of historical land uses and views of the prairie over time is also included. The author's deep interest and enjoyment of the prairie is delicately sprinkled throughout the text.

Take a sentimental journey with author Matt White and experience his excitement in exploring Blackland Prairie remnants in Texas. White shares both joyous experiences of preserving remnants and heartbreaking defeats in loss of Blackland Prairie areas. Readers with an interest in learning more about the Blackland Prairie should seek out this very readable book—it includes many details on the natural history and ecology of the Blackland Prairie within the author's stories.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

POA MATRI-OCCIDENTALIS (POACEAE: POOIDEAE: POEAE: POINAE), A NEW SPECIES FROM MEXICO

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ABSTRACT

Poa matri-occidentalis P.M. Peterson & Soreng, sp nov., is described and illustrated. ***Poa matri-occidentalis*** subsp. ***matri-occidentalis*** is known from steep rocky slopes of Cerro Gordo, Durango, and ***Poa matri-occidentalis*** subsp. ***mohinorensis*** Soreng & P.M. Peterson, subsp. nov. is known from rocky cliffs of Cerro Mohinora, Chihuahua. The new species is morphologically similar to *Poa kelloggii* but differs by having leaf sheaths that are closed near the base 2/3 to 4/5 their length, entire ligules that are 3.5–6 mm long, nodding panicles, ovate lemmas with obtuse to acute apices, and non-visible rachilla internodes. A key distinguishing 11 species now reported from northern México is provided.

RESUMEN

Se describe e ilustra **Poa matri-occidentalis** P.M. Peterson & Soreng, sp. nov. ***Poa matri-occidentalis*** subsp. ***matri-occidentalis*** se encuentra en la zona de cuestas rocosas escarpadas de Cerro Gordo, Durango, y ***Poa matri-occidentalis*** subsp. ***mohinorensis*** Soreng & P.M. Peterson, subsp. nov. se encuentra en la zona de laderas rocosos del Cerro Mohinora, Chihuahua. La nueva especie es morfológicamente similar a *Poa kelloggii* pero difiere de ésta última por tener las vainas de las hojas cerradas en la parte inferior de la base de 2/3 a 4/5 de su longitud, por tener lígulas enteras de 3.5–6 mm de largo, panículas recurvadas, lemas ovadas con ápices agudos a obtusos y raquilla con entrenudos no-visibles. Se proporciona una clave para distinguir las 11 especies reportadas actualmente del norte de México.

Poa L. is the largest genus of grasses, including some 500–575 species that occur in a wide range of habitats from throughout the World (Soreng 1990; Gillespie & Soreng 2005). The genus is characterized by having rather small, multi-flowered spikelets, lemmas that are keeled, unawned, usually 5-nerved, commonly with web-like hairs emerging from the dorsal side of the callus, caryopses that are firm with lipid and a short hilum, lodicules that are broadly lanceolate with a lateral lobe, leaf sheaths closed above the base more than 1/20 the entire length, leaf blades that generally have two rows of bulliform cells (one on either side of the midnerve, these appearing as railroad tracks) and no additional rows of bulliform cells, and blades commonly with naviculate (boat-shaped) apices (Soreng, in press). *Poa* has been divided into subgenera and sections and subsections for North America (Soreng 1998; Soreng in press), the New World (Soreng et al. 2003a), and the World (Gillespie et al. 2006; Zhu et al. 2006).

Northern México (excluding Baja California and Baja California Sur) is not thought to be especially rich in *Poa* species. The following 11 species have been reported from the states of Aguascalientes (Ags), Chihuahua (Chih), Coahuila (Coah), Durango (Dur), Jalisco (Jal), Nuevo León (NL), San Luis Potosí (SLP), Sonora (Son), Tamaulipas (Tamp), and Zacatecas (Zac): *Poa annua* L. (Ags, Chih, Coah, Dur, Jal, NL, SLP, Tamp, Zac), *P. bigelovii* Vasey & Scribn. (Chih, Coah, NL, Son), *P. compressa* L. (Coah), *P. conglomerata* Rupr. (= *P. scaberula* Hook. f.) [Coah is an error since a specimen (*J.A. Garcia 49*) cited in Beetle et al.

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(1999) is = *P. pratensis* L.], *P. fendleriana* (Steud.) Vasey [includes *P. fendleriana* subsp. *albescens* (Hitchc.) Soreng] (Chih, Coah, Son, Zac), *P. infirma* Kunth (listed as synonym of *P. annua* and probably with similar distribution), *P. mulleri* Swallen (NL), *P. orizabensis* Hitchc. (NL possibly an error for *C.H. & M.T. Mueller 1248* from Cerro Potosí as determined by A.A. Beetle = *P. mulleri*!, SLP-not yet verified by us from there), *P. pratensis* (Chih, Coah, NL), *P. ruprechtii* Peyr. [includes *P. sharpii* Swallen as a synonym] (Coah, NL,), and *P. strictiramea* Hitchc. (Chih, Coah, Dur, NL, Zac) [Beetle et al. 1999; Espejo Serna et al. 2000; Hitchcock 1913]. Of the 10 species known from the region, *P. annua, P. compressa, P. infirma*, and *P. pratensis* are introduced, and *P. bigelovii, P. fendleriana, P. mulleri, P. orizabensis, P. ruprechtii*, and *P. strictiramea* are native. The annuals, *P. annua* and *P. infirma* have been placed in *Poa* sect. *Micrantherae* Stapf, and *P. bigelovii* was placed in *Poa* sect. *Homalopoa* Dumort. (Soreng et al. 2003a). Of the remaining natives, *P. mulleri, P. orizabensis, P. ruprechtii*, and *P. strictiramea* have been placed in *Poa* sect. *Homalopoa s.l.*, and *P. fendleriana* was placed in *Poa* sect. *Madropoa* Soreng (Soreng et al. 2003a).

While making determinations of material in the field using Las Gramíneas de Durango (Herrera Arrieta 2001) and then checking the herbarium at Centro Interdiciplinario de Investigación para el Desarrollo Integral Regional (CIIDIR) in Durango, the first author recognized the unique features of a recent collection from Cerro Gordo. Upon further inspection of collections on loan from various herbaria for a complete revision of *Poa* in México, the second author discovered another, generally pubescent form, occurred near Cerro Mohinora, Chihuahua. The third author then contributed the anatomical portion. We describe these two new forms as a new species of *Poa* with two subspecies. The new species with two subspecies is clearly aligned within subfamily Pooideae, tribe Poaeae, and subtribe Poinae (Soreng et al. 2003a, 2003b, 2005).

Poa matri-occidentalis P.M. Peterson & Soreng, sp. nov. (**Figs. 1a–c; 2c–l**). TYPE: MÉXICO. DURANGO: Sierra Madre Occidental, SW slope of Cerro Gordo just below twin rock outcrops (23°12'32.5"N-104°56'54.1"W), 3130–3200 m, 26 Sep 2005, *P.M. Peterson 19145 & F. Sánchez Alvarado* (HOLOTYPE: US!; ISOTYPES CIIDIR!; MEXU!).

A *Poa kelloggii* Vasey vaginibus connatus 2/3–4/5 longe lateque, ligulis 3.5–6 mm longis integris, paniculus nutans, lematibus ovatis apicibus obtusus ad acutus, rachillibus no visibilis, recedit.

Loosely caespitose and rhizomatous perennials with intra and extravaginal basal branching. Culms 45–80 cm tall, solitary to several, erect or bases slightly decumbent, terete or weakly compressed; nodes 2–4, terete, glabrous and smooth, 1–3 exserted. Leaf sheaths mostly 3–14 cm long, closed about 2/3 to 4/5 their length, compressed, glabrous and smooth, or sometimes the lower ones retrorsely scabrous to puberulent and with ciliate collars, most sheaths 0.4–1.1 times as long as their blades; collars smooth or with a few hooks, glabrous or ciliate; ligules 3.5–6 mm long, membranous to hyaline, glabrous and smooth, or sometimes puberulent, apex obtuse to acute, entire; blades 2–6 mm wide, flat, abaxial nerves and margins lightly scabrous, adaxially smooth, glabrous throughout, apices narrowly prow-shaped; flag blades 12–22 cm long. Panicles 12–26 cm long, nodding, pyramidal, open, sparse with 24–85 spikelets, longest internodes 2.5–5.5 cm long; branches (1–)2(–3) at the lower nodes, longest 5.5–10 cm long bearing 3–15 spikelets, ascending to spreading, lax, angled, the angles sparingly scaberulous. Spikelets 4–8 mm long, 1.8–2.7 mm wide, laterally compressed, greenish to stramineous, florets 2 or 3, perfect, occasionally the upper floret is much reduced and sterile; lower rachilla internodes 1–2 mm long, usually not visible, glabrous, smooth; glumes equal to subequal, lanceolate,



FIG. 1. *Poa matri-occidentalis* subsp. *matri-occidentalis* (*Peterson 19145 & Sánchez Alvarado*). **A.** Habit. **B.** Inflorescence. **C.** Sheath, ligule, and blade. *Poa matri-occidentalis* subsp. *mohinorensis* (*Nesom 6475 & McDonald*). **D.** Sheath, ligule, and blade.

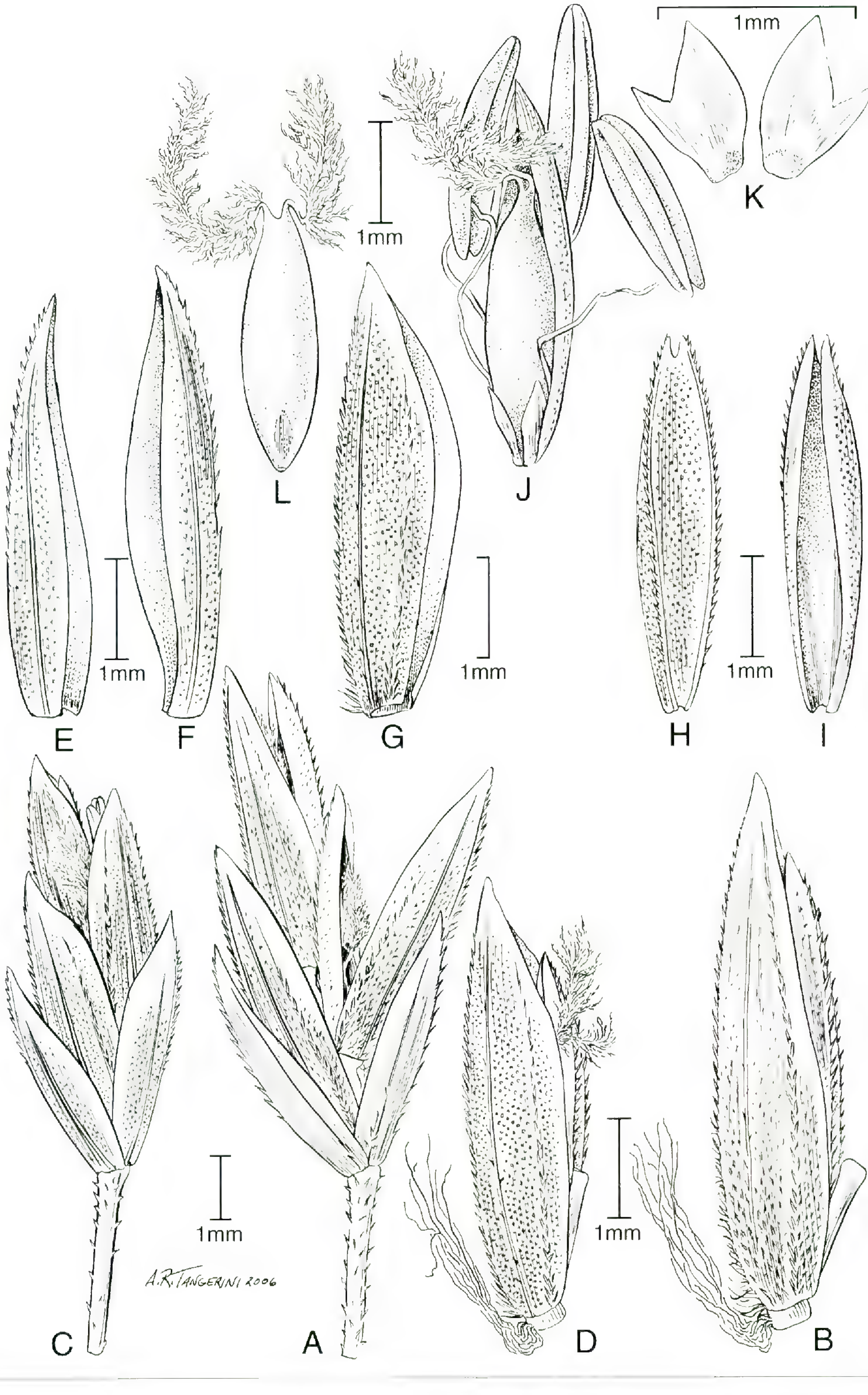


FIG. 2. *Poa matri-occidentalis* subsp. *mohinorensis* (*Nesom 6475 & McDonald*). **A.** Spikelet. **B.** Floret. *Poa matri-occidentalis* subsp. *matri-occidentalis* (*Peterson 19145 & Sánchez Alvarado*). **C.** Spikelet. **D.** Floret. **E.** Lower glume. **F.** Upper glume. **G.** Lemma. **H.** Palea, dorsal view. **I.** Palea, ventral view. **J.** Stamens, ovary, and lodicules enclosed in palea. **K.** lodicules. L. Young caryopsis.

scabrous along the upper keel, distinctly keeled, 3-nerved, the lateral nerves often only evident near base, scaberulous along the nerves, apex acute to acuminate, often appearing mucronate because the margins are often involute, margins hyaline; lower glumes 3–5 mm long, lanceolate to ovate usually shorter than the upper; upper glumes 3.7–5.6 mm long, ovate to obovate, wider that the lower with more prominent nerves; calluses with cob-webby hairs, the hairs about 1/2 to 1/3 the length of the lemma; lowest lemmas 4.6–6.3 mm long, ovate, distinctly keeled, surfaces between nerves finely muriculate (with minutely pointed, whitish bumps on the short cells) or sometimes densely scabrous, 5-nerved, the lateral nerves moderately prominent, keel and lateral nerves scabrous, keel and marginal nerves glabrous or sometimes puberulent below, margins hyaline, apex obtuse to acute; lowest paleas 4.4–6 mm long, usually a little shorter than the lemmas, strongly laterally compressed with a deep adaxial furrow between the nerves, muriculate, scabrous along the nerves; anthers 2–2.2 mm long, yellow; lodicules 2, membranous; ovary glabrous. Caryopses 2.6–2.9 mm long, fusiform, light brownish.

Phenology.—Flowering August through October.

Comments.—The new species can be distinguished from *Poa kelloggii* by having leaf sheaths that are closed near the base 2/3 to 4/5 their length, entire ligules that are 3.5–6 mm long, nodding panicles, ovate lemmas with obtuse to acute apices, and non-visible rachilla internodes.

Poa matri-occidentalis subsp. **matri-occidentalis** (**Figs. 1a–c; 2c–l; 3a–c; 4**).

Lower leaf sheaths glabrous and smooth; collars smooth or with a few hooks, glabrous; ligules glabrous and smooth. Lowest lemmas 4.7–5.4 mm long, surfaces between nerves finely muriculate (with minutely pointed, whitish-bumps on the short cells), keel and marginal nerves scabrous, glabrous throughout.

Distribution and habitat.—Known only from a single locality at Cerro Gordo, Durango, between 3130–3200 m where the species was found growing on steep, rocky, and grassy slopes beneath open forests of *Pseudotsuga menziesii* (Mirb.) Franco, *Quercus* sp., *Pinus* spp., with other associates, such as: *Arctostaphylos pungens* Kunth, *Bromus carinatus* Hook. & Arn., *B. richardsonii* Link, *Aegopogon cenchroides* Humb. & Bonpl. ex Willd., *Trisetum viride* (Kunth) Kunth, *Festuca* sp., *Carex* sp., and *Agrostis* sp.

Leaf anatomy.—Cross-sections were done by hand on re-hydrated material then mounted on temporary slides and stained with concentrated safranin. A diagram of a cross-section and abaxial leaf scrape were made with the aid of a camera lucida (Figs. 3a–c, 4).

Cross-section view (Fig. 3a–c.).—The lamina are V-shaped with primary, secondary, and tertiary vascular bundles of decreasing size. The primary vascular bundles are well differentiated into xylem with metaxylem, phloem, and a double bundle sheath (mestome and parenchyma bundle sheath). The ribs are rounded and furrows are <1/5 as deep as the width of the blade adaxially and abaxially. Abaxial projection of the midrib caused by inflated parenchyma cells and sclerenchyma is conspicuous. In half-the-width of the blade there is a single primary vascular bundle comprising the midvein; 3–4 additional primary vascular bundles; 3–4 secondary vascular bundles placed between consecutive tertiary vascular bundles; 7–8 tertiary vascular bundles placed between each consecutive primary and secondary vascular bundles; and two tertiary vascular bundles at the margin (i-iii-ii-iii-i-iii-ii-iii-i-iii-ii-iii-i-iii-ii-iii-iii). All vascular bundles are placed in the median layer of the blade and are round in outline. The xylem of the primary vascular

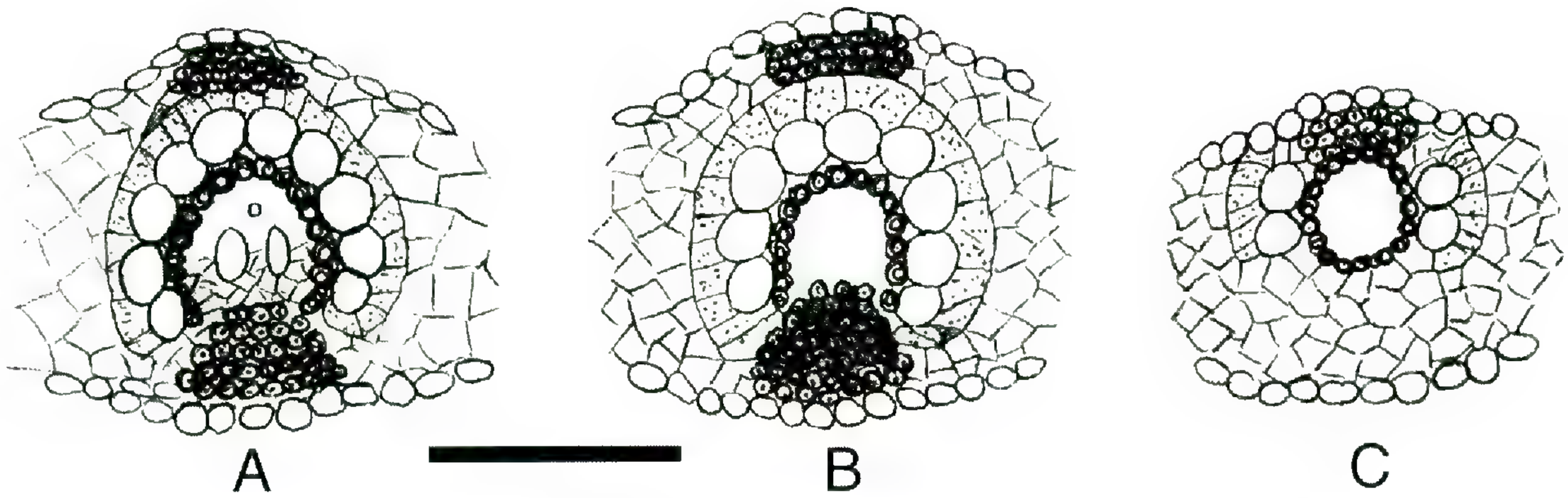


FIG. 3. Cross-section leaf blade anatomy of *Poa matri-occidentalis* subsp. *matri-occidentalis* (*Peterson 19145 & Sánchez Alvarado*), adaxial surface uppermost in all drawings. **A.** Primary vascular bundle. **B.** Secondary vascular bundle. C. Tertiary vascular bundle. Scale bar = 50um.

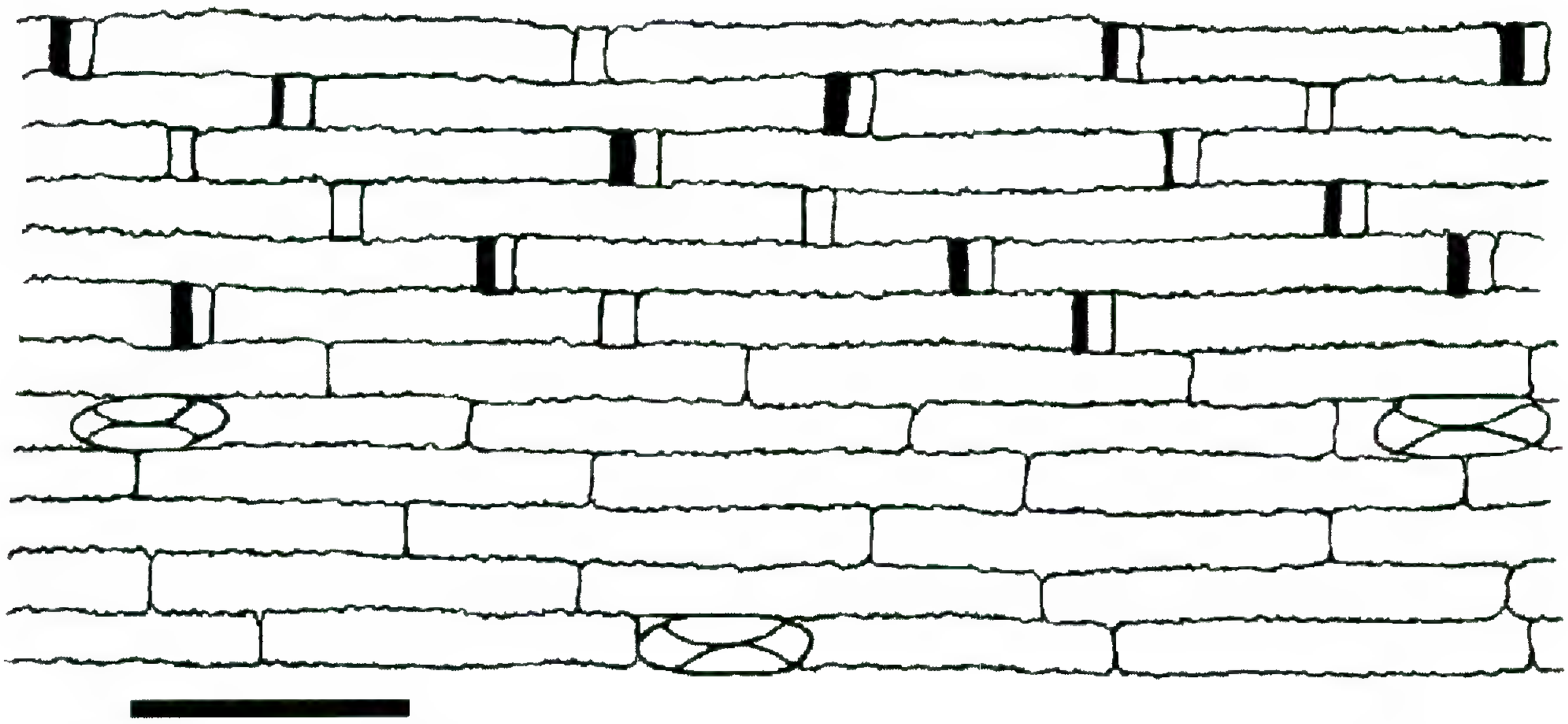


FIG. 4. Abaxial leaf epidermis of *Poa matri-occidentalis* subsp. *matri-occidentalis* (*Peterson 19145 & Sánchez Alvarado*) showing long cells, silica bodies (dark), cork cells (clear), and three stomata. Scale bar = 50um.

bundles contains two or occasionally three metaxylem vessels adjacent to the phloem, that are larger than the parenchyma bundle sheath cells, and sometimes one or two protoxylem vessels are located adaxially to the phloem. The mestome, or inner sheath, is always present in primary and secondary vascular bundles surrounding the xylem and phloem. The Mestome is composed of small cells with thick walls and interrupted abaxially by sclerenchyma fibers forming a girder in primary and secondary bundles, except in the central primary vascular bundle where it is continuous surrounding the bundle and the sclerenchyma is separated from the bundle by colorless cells and centered at the very bottom of a conic abaxial base. The parenchyma bundle sheath, or outer layer, contains large, thin-walled cells; 10–12 cells are present on the continuous adaxial half circle of the primary vascular bundle sheath; 6–8 cells are present in the secondary vascular bundles; and the number of cells varies between three and four on each side of the interrupted tertiary vascular bundles. Chlorenchyma cells surround the bundles and are conspicuously continuous between the vascular bundles in a loose arrangement. Five

to eight sclerenchyma fibers are present adaxially in all bundles. Five to eight rows of sclerenchyma fibers form the abaxial girders of the primary and secondary vascular bundles, which widen near the epidermis and narrow toward the vascular bundle. Deep fan-shaped rows of bulliform cell are located adaxially near the central part of the blade between the central primary vascular bundle and two lateral tertiary vascular bundles; these are continuous to adaxial epidermal cell walls.

Epidermis in abaxial view (Fig. 4).–Costal and intercostals zones are clearly distinguishable. Three to six rows of short cells are found in the costal zone, each separated by a row of long cells. Irregularly-shaped silica bodies are alternate and adjacent to short cells of the costal zone. Cork cells are less frequent and the same shape as the silica bodies. Fifteen to seventeen rows of long cells are common in the intercostal zone. Long cells are 8–10 times longer than wide with wavy cell walls. No papillae or hairs are present. Low dome-shaped stomata are infrequent and found in single row. Parallel subsidiary cells are rounded in outline. A few antrorse bristles are present at foliar margin.

Poa matri-occidentalis subsp. **mohinorensis** Soreng & P.M. Peterson, subsp. nov. (**Figs. 1d; 2a, b**). TYPE: MÉXICO. CHIHUAHUA: Municipio de Guadalupe y Calvo, Sierra Madre Occidental, N side of Cerro Mohinora, ca. 13 mi SW of Guadalupe y Calvo, open pine-fir woods with scattered spruce, nearly vertical, N-facing rock wall, very moist with many bryophytes and rich herbaceous flora (25°57'N-107°03'W), 2950 m, 20 Aug 1988, *G. Nesom 6475 & A. McDonald* (HOLOTYPE: TEX!; ISOTYPE ARIZ).

A *Poa matri-occidentalis* subsp. *matri-occidentalis* vaginae disatalibus et lemmatae carina puberulens, internervibus scabris, differt.

Lower leaf sheaths retrorsely scabrous to puberulent; collars ciliate; ligules puberulent. Lowest lemmas 4.6–6.3 mm long, surfaces between the nerves densely scabrous, keel and marginal nerves scabrous and puberulent below.

Distribution and habitat.—Known only from Cerro Mohinora, Chihuahua between 2950–3130 m, on moist, rocky cliffs and ledges associated with open forests of *Pinus*, *Abies*, and *Picea*.

Additional specimen examined. **MÉXICO. Chihuahua:** Municipio de Guadalupe y Calvo, Sierra Madre Occidental, on high ledges on summit of Cerro Mohinora (25°57 N-107°03'W), 10,000–10,300 ft, 16–17 Oct 1959, *D.S. Correll 23177 & H.S. Gentry* (LL).

DISCUSSION

Based on morphological similarity to *Poa kelloggii*, endemic to California, *P. matri-occidentalis* is tentatively placed in *Poa* sect. *Sylvestres* V.L. Marsh ex Soreng. *Poa* sect. *Sylvestres* as treated for the genus in the Flora of North America, includes seven species, all of which are endemic to forests in the U.S.A. and southern Canada (Soreng in press).

[*Poa* sect. *Sylvestres* slightly modified from Soreng in press] "Plants perennial; usually non-rhizomatous and non-stoloniferous, sometimes shortly rhizomatous, usually loosely tufted, infrequently densely tufted. Basal branching mainly pseudointravaginal, or sometimes mainly extravaginal. Culms 20–126 cm, terete or weakly compressed. Sheaths closed (1/20)1/3 to about their full length, terete or weakly keeled, basal sheaths readily deteriorating; ligules 0.1–3(–4) mm long, smooth or sparsely scabrous, truncate to obtuse, entire or lacerate, smooth or ciliolate; blades smooth or scabrous, glabrous, apices narrowly prow-shaped. Panicles 4–36 cm long, erect or lax, pyramidal or lanceoloid, usually sparse, lower rachis internodes usually longer than (2–)3 cm, nodes with 1–10 branches; branches ascending to spreading or eventually reflexed, lax or straight, angled, angles scabrous, spikelets confined to distal 1/5–1/3(–1/2). Spikelets 2.5–8.2 mm long,

laterally compressed; florets (1–)2–5(–6), normal; rachilla internodes smooth, usually glabrous, sometimes hairy, hairs to 0.2 mm long. Glumes distinctly keeled, scabrous on the keel and nerves; calluses terete or slightly laterally compressed, usually dorsally webbed, sometimes glabrous; lemmas 2.1–5 mm long, lanceolate to broadly lanceolate, distinctly keeled, glabrous or hairy, apices with narrow, clear or white margins; palea keels scabrous, glabrous or with hairs over the keels; anthers 3, 0.4–2(–2.6) mm long."

Based on DNA sequence analyses, *Poa* sect. *Sylvestres* is the earliest diverging section in the genus, if *Arctopoa* (Griseb.) Prob. is excluded, as we now believe it should be (Gillespie et al. in prep.). However, the new species differs in some respects from all or most of the other species in the section. Like *P. kelloggii*, *P. matri-occidentalis* is short rhizomatous and its basal branching is primarily extravaginal. *Poa matri-occidentalis* differs from all the other species in the section by having longer ligules (3.5–6 mm long). If the new species is confirmed to belong to this section (viz. DNA sequence analysis) it would be the first report from outside the U.S.A. and Canada. Our only hesitation to placing the new species in this section is that there is some morphological overlap with *Poa* sect. *Homalopoa* s.l. and with the *P. nervosa* (Steud.) Vasey complex of *Poa* sect. *Madropoa*, and currently, there are no DNA data for the new species. In *Poa* sect. *Madropoa*, through subsp. *mohinorensis*, *P. matri-occidentalis* most closely approaches *P. tracyi* Vasey from New Mexico and Colorado U.S.A. (as noted on the 1989 annotation by J.R. and C.G. Reeder on *Nesom 6475*), and "*P. ruprechtii* Peyr." (as that name is applied to material from the Sierra Madre Oriental, México). *Poa matri-occidentalis* differs from both these species by having muriculate or short-pubescence on the lemmas and only perfect florets. The new species differs from "*P. ruprechtii*" by having longer glumes that are also proportionally longer relative to the adjacent lemmas and by fewer florets per spikelet. We suspect the name *P. ruprechtii* Peyr. s. str. may be misapplied in northern México's Sierra Madre Oriental as material called this by Hitchcock (1913) and Fournier (1886), from the region of the type locality, in the State of México and Distrito Federal, differs in having short anthers, and more indurate and prominently nerved lemmas with relatively longer glumes, but we have yet to locate and examine a type specimen of *P. ruprechtii*. If our suspicion is correct, the Sierra Madre Oriental plants probably represent an additional new species.

A key to all known or reported species from northern México follows. In this key all measurements were taken from the lowest, one or two florets in the best-developed spikelets.

KEY TO THE SPECIES OF *POA* IN NORTHERN MÉXICO

1. Plants annual; palea keels pubescent in part.
   2. Callus with cobwebby hairs; panicles contracted _____ **P. bigelovii**
   2. Callus glabrous; panicles open.
      3. Anthers 0.6–1 mm long _____ **P. annua**
      3. Anthers 0.2–0.5 mm long _____ **P. infirma**
1. Plants perennial; palea keels scabrous only.
   4. Anthers 0.5–1 mm long callus webbed.
      5. Lemmas glabrous or very sparsely puberulent on the keel base; spikelets broadly ovate _____ **P. orizabensis**
      5. Lemmas short villous on the keel and lateral nerves and sometimes puberulent between the nerves; spikelets broadly lanceolate (of Distrito Federal and State of México) _____ **P. ruprechtii**
   4. Anthers 1.2–3 mm long; callus glabrous or pubescent.
      6. Plants without rhizomes or lateral tending shoots, densely tufted, vegetative shoots mainly intravaginal.

7. Upper glumes (3–)5–7-nerved; lemmas pubescent on lower half of the keel; longest branches up to 3.5–3.8 cm long; plants 20–42 cm tall _____ **P. mulleri**
7. Upper glumes 3-nerved; lemmas glabrous or very sparsely puberulent on the keel and marginal nerves near the base; longest branches up to 10 cm long; plants mostly (20–) 40–100 cm tall _____ **P. strictiramea**

6. Plants with rhizomes or lateral tending extravaginal snoots, densely to loosely tufted, vegetative shoots intravaginal and extravaginal or mostly extravaginal.
8. Panicles contracted, fairly dense; uppermost leaf blades highly reduced or absent; populations dioecious or pistillate; callus glabrous.
9. Lemmas glabrous _____ **P. fendleriana** ssp. **albescens**
9. Lemmas pubescent on the keel and marginal nerves _____ **P. fendleriana** ssp. **fendleriana**

8. Panicles loosely contracted to wide open; uppermost leaf blades well-developed; plants all perfect flowered, or, if pistillate in part, then panicles open; callus, at least of proximal lemmas, with cobwebby hairs or glabrous.
10. Lemmas glabrous or sparingly puberulent near the base of the keel; upper glumes 3.7–5.6 mm long; ligules obtuse to acute, 3–6 mm long.
11. Sheaths of lower leaves retrorsely scabrous to puberulent; collars ciliate; lemmas densely scabrous between the nerves, keels and marginal nerves nerves puberulent below _____ **P. matri-occidentalis** ssp. **mohinorensis**
11. Sheaths of lower leaves smooth, glabrous, collars smooth or with a few hooks, glabrous; lemmas finely muriculate between the nerves, keel and marginal nerves glabrous below _____ **P. matri-occidentalis** ssp. **matri-occidentalis**

10. Lemmas distinctly pubescent on the keel and marginal nerves; ligules truncate to obtuse, 1–3 mm long.
12. Culms and nodes strongly compressed, keeled _____ **P. compressa**
12. Culms and nodes terete, or culms weakly compressed.
13. Rachilla internodes mostly hidden from view; spikelets mostly 3–6 mm long; lemmas glabrous between the keel and marginal nerves; ligules truncate, entire, usually 1–2 mm long _____ **P. pratensis**
13. Rachilla internodes exposed; spikelets 4.5–8 mm long; lemma surfaces (at least the proximal most ones) with hairs between the keel and marginal nerves near the base; ligules obtuse, irregularly dentate, to 3 mm long (of Sierra Madre Oriental) _____ **"P. ruprechtii"**

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BROMUS AYACUCHENSIS (POACEAE: POOIDEAE: BROMEAE), A NEW SPECIES FROM PERU, WITH A KEY TO *BROMUS* IN PERU

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ABSTRACT

Bromus ayacuchensis, a new species from Departamento Ayacucho, Peru, is described and illustrated. The new species is similar to species in *Bromus* sect. *Ceratochloa*, particularly *B. cebadilla*, because of its strongly keeled lemmas. It differs from *B. cebadilla* by having densely pilose culms near the base, adaxially pilose ligules 3–6.6 mm long, lower glumes 1-veined, upper glumes 3-veined, pilose lemmas (especially along the margins and near the apex), lemma margins that are tightly involute on lower 1/5–1/4, and lemma awns 3–5.5 mm long. Phylogenetic analyses of sequence data from the internal transcribed spacer regions of nuclear ribosomal DNA place *B. ayacuchensis* in a clade with species of sect. *Ceratochloa*, whereas analyses of plastid data from the *trn*L intron and the 3'-end of *ndh*F indicate that *B. ayacuchensis* is closely related to this clade. Confirmed records are provided for *B. modestus* and *B. cebadilla* in Peru, and *B. coloratus* and *B. flexuosus* are reported for the first time in Peru. A key to the 12 species of *Bromus* now known from Peru is included.

RESUMEN

Se describe y se ilustra **Bromus ayacuchensis** Saarela & P.M. Peterson, sp. nov., una nueva especie del Departamento de Ayacucho, Perú. La nueva especie es similar a las especies de *Bromus* secc. *Ceratochloa*, particularmente *B. cebadilla*, porque tiene lemas muy carenadas. Se diferencia de *B. cebadilla* por tener cúlmenes densamente pilosos cerca de la base, lígulas 3 6.6 mm de largo y pilosas en la parte ventral superior, glumas inferiores con 1 nervio, glumas superiores con 3 nervios, lemas pilosos (especialmente a lo largo de los márgenes y cerca del ápice), los márgenes del lema son firmemente involutos en la porción 1/5–1/4 inferior del lema y aristas de 3–5.5 mm de largo. Los análisis filogenéticos de los datos de la secuencia de ADN de las regiones transcritas internas del espaciador ribosómico nuclear colocan a *B. ayacuchensis* en un clado con las especies de la sect. *Ceratochloa*, mientras que los análisis de los datos del intrón del plástido del *trn*L y de los extremos 3' del *ndh*F indican que *B. ayacuchensis* está íntimamente relacionado pero no es parte de este clado. Proporcionamos ejemplares de especimenes *B. modestus* y *B. cebadilla* provenientes del Perú, y *B. coloratus* y *B. flexuosus* encontrados por primera vez en Perú. Se incluye la clave para las 12 especies de *Bromus* conocidas en Perú.

Bromus L. (Poaceae: Pooideae: Bromeae) is a large genus of grasses with over 160 species distributed throughout temperate regions of the world (Clayton & Renvoize 1986). Some species are important forage grasses (e.g., *B. inermis* Leyss.; *B. auleticus* Trin. ex Nees), and many are highly aggressive, invasive weeds (e.g., *B. diandrus* Roth; *B. madritensis* L.; *B. tectorum* L.; Pavlick 1995).

Bromus is distinguished from other grass genera by the combination of leaf sheath

margins that are connate (closed) for most of their length, awns that are inserted subapically on the lemmas (except in *B. lepidus* Holmb. and *B. bidentatus* Holmström & H. Scholz; Holmstrom & Scholz 2000), hairy apical bilabiate-appendages of the ovary, and simple starch grains (Wagnon 1952; Smith 1970; Clayton & Renvoize 1986).

Bromus is diverse morphologically and has been divided variously into segregate genera [*Anisantha* C. Koch, *Boissiera* Hochst. ex Steud., *Bromus*, *Bromopsis* (Dumort.) Fourr., *Ceratochloa* P. Beauv., *Nevskiella* Kreczetowicz & Vvedensky, and *Trisetobromus* Nevski], subgenera [*Bromus*, *Stenobromus* (Hack.), *Festucaria* Gren. & Godr., *Ceratochloa* (P. Beauv.) Hack., *Nevskiella* (Kreczetowicz & Vvedensky) Kreczetowicz & Vvedensky, and *Neobromus* Shear; Stebbins 1981] or sections [*Bromus*, *Triniusia* (Steud.) Nevski., *Boissiera* (Hochst. ex Steud.) P. M. Sm., *Genea* Dumort., *Bromopsis* Dumort., *Ceratochloa* (P. Beauv.) Griseb., *Nevskiella* (Kreczetowicz & Vvedensky) Tournay, and *Neobromus* (Shear) Hitchc.; Smith 1970]. Most recent workers use a sectional classification (e.g., Clayton & Renvoize 1986; Pavlick 1995; Planchuelo & Peterson 2000; Pavlick et al. 2003).

Molecular studies (Pillay & Hilu 1990, 1995; Ainouche & Bayer 1997; Saarela et al. in press) support the monophyly of some of these sections (e.g., *Bromus* sects. *Bromus*, *Genea*, *Ceratochloa*), and have indicated that others comprise several distinct lineages (e.g., *Bromus* sect. *Bromopsis*). Incongruence between plastid and nuclear ribosomal gene trees has provided tentative insight into past hybridization events in the genus (Saarela et al. in press). The available classification schemes (e.g., Smith 1970) do not satisfactorily reflect evolutionary relationships in the genus as understood currently (Saarela et al. in press).

Approximately 80 native and introduced species of *Bromus* are recognized currently in North, South, and Central America (Pavlick et al. 2003). Many regional treatments of *Bromus* have been published (Wagnon 1952; Soderstrom & Beaman 1968; Cámara Hernández 1978; Pinto-Escobar 1981, 1986; Matthei 1986; Pavlick 1995; Gutiérrez & Pensiero 1998; Planchuelo & Peterson 2000; Pavlick et al. 2003), cytological, genetical, and anatomical studies are revealing new information (e.g., Martinello & Schifino-Wittman 2003; Ramos et al. 2002; Fu et al. 2005; Tuna et al. 2005, 2006), taxonomic studies are clarifying species circumscriptions (e.g., Naranjo et al. 1990; Planchuelo 1991; Naranjo 1992; Peterson et al. 2002; Oja et al. 2003; Massa et al. 2001, 2004; Saarela et al. 2005) and new taxa are being described (e.g., Matthei 1986; Renvoize 1994; Peterson & Planchuelo 1998).

On a recent trip to Peru, the second and third authors collected several unusual individuals of *Bromus* with strongly keeled (laterally flattened) lemmas, 1-veined lower glumes, and 3-veined upper glumes. Strongly keeled lemmas are characteristic of sect. *Ceratochloa*, but all known species from this section have 3–9-veined lower glumes and 5–9-veined upper glumes (Smith 1970). Known species of *Bromus* that have 1- and 3-veined lower and upper glumes, respectively, have lemmas that are wide and short, rounded, or slightly keeled (Smith 1970). A review of the taxonomic literature and specimens in the US National Herbarium has indicated that no individuals of *Bromus* with this combination of characters have been described previously. We name and describe these recent collections as a new species, *Bromus ayacuchensis*. We discuss the phylogenetic placement of the new species in the genus based on its morphology and DNA sequence data from the internal transcribed spacer (ITS) regions of nuclear ribosomal DNA, the plastid *trn*L(UAA) intron, and the 3'-end of the plastid *ndhF* gene.

MATERIALS AND METHODS

The morphological description of the new species is based on material from three collec-

tions (see below). Fifteen specimens were measured for the morphological description. To characterize leaf anatomy, leaf blades were field collected, and segments of about 5 mm in length from the middle of the second leaf blade below the inflorescence of the flowering culm were fixed in FPA (formalin: propionic acid: ethyl alcohol: water; 2:1:10:7). Leaf blades were desilicified in 30%-hydrofluoric acid for 48 hours. Leaf blade segments were dehydrated, embedded, sectioned, and stained following the methods described in Columbus (1999). Terminology used in the anatomical description follows Metcalfe (1960) and Acedo & Llamas (1999).

DNA was obtained from field collected leaf material of two collections (*Peterson 16452 & Refulio-Rodríguez* and *Peterson 18212 & Refulio-Rodríguez*). Voucher specimens are deposited in US. Sequence data were obtained for *B. ayacuchensis* from the plastid *trn*L(UAA) intron, the 3'-end of the plastid *ndh*F gene, and the internal transcribed spacer (ITS) regions of nuclear ribosomal DNA, following the protocol in Saarela et al. (in press). Sequences for all regions from both individuals were identical, thus a single consensus sequence was generated for each region. Sequence data have been deposited in GenBank with the following accessions: (ITS: DQ676867; 3' *ndh*F: DQ676868; *trn*L intron: DQ676866). The new sequence data were added to an existing matrix that includes sequence data from 46 species of *Bromus* that represent a large proportion of the morphological and geographical diversity in the genus (Saarela et al. in press). Heuristic searches using parsimony were conducted independently on the nuclear ribosomal DNA and combined plastid data sets with 100 random starting trees, tree-bisection-reconnection (TBR) branch swapping, and all character and character-state changes equally weighted. Branch support was assessed using maximum parsimony bootstrap analysis (Felsenstein 1985) from 500 replicates using the heuristic search option, with one random starting tree, TBR branch swapping, and MaxTrees set to 500 per replicate.

RESULTS AND DISCUSSION

Morphological and molecular data suggest that *B. ayacuchensis* is similar to species classified in *Bromus* sect. *Ceratochloa*. *Bromus ayacuchensis* shares the strongly laterally compressed spikelets with species in sect. *Ceratochloa*, and the nuclear ribosomal trees include it in a clade with species of *Bromus* sect. *Ceratochloa* (BS=92%; Fig. 1a). *Bromus* sect. *Ceratochloa* is native to North and South America, characterized by a perennial habit, ovate-lanceolate strongly laterally compressed spikelets, 3–5-veined lower glumes, 5–7-veined upper glumes, and strongly keeled lemmas (Smith 1970). All taxa in the section are polyploids (octo-, hexa-, and 12-ploid) (Stebbins 1981; Pavlick 1995). In the first complete synopsis of *Bromus* in South America, Planchuelo & Peterson (2000) recognized nine species in sect. *Ceratochloa*. A recent taxonomic study has proposed the lumping of several hexaploid taxa from Patagonia [*B. catharticus* Vahl, *B. cebadilla* Steud. (syn. = *B. stamineus* E. Desv.), *B. coloratus* Steud., *B. lithobius* Trin., *B. mango* E. Desv., and *B. tunicatus* Phil] into one morphologically variable species, *B. catharticus* (Massa et al. 2001, 2004). Other species of sect. *Ceratochloa* recognized currently in South America include *B. bonariensis* Parodi & J.A. Cámara, an endemic of Provincia Buenos Aires, Argentina, and *B. striatus* Hitchc., an endemic of Peru (Planchuelo & Peterson 2000; Pavlick et al. 2003). These species were outside of the geographic scope of the studies by Massa et al. (2001, 2004), but both have been considered conspecific with *B. catharticus* in the past (Pinto-Escobar 1986; Planchuelo 1991). Among these taxa, *B. ayacuchensis* is most similar to *B. cebadilla*, a species known from Argentina, Chile, Peru, and the USA (Pavlick et al. 2003).

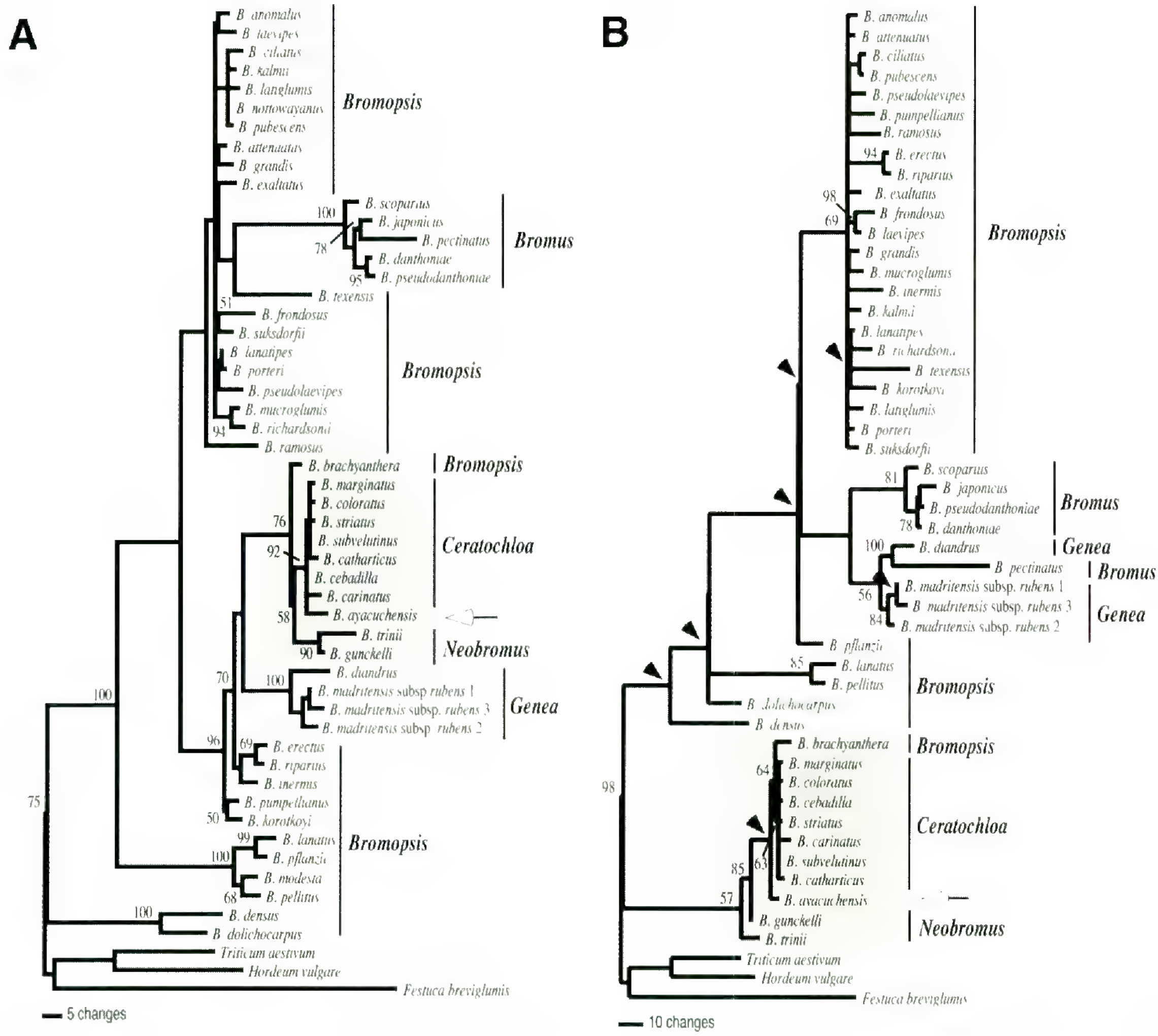


FIG. 1. Phylogenetic position of *Bromus ayacuchensis* based on sequence data from: (**A**) the internal transcribed spacer (ITS) regions of nuclear ribosomal DNA. The position of *B. ayacuchensis* in each tree is indicated with an open arrow. Bootstrap support values are indicated above or below the branches. Clades that collapse in the strict consensus tree are indicated with diagonal arrows. Traditionally recognized sections in *Bromus* (sensu Smith 1970) are indicated to the right of the trees; and (**B**) the combined plastid *trn*L intron and 3′-end of *ndh*F.

Bromus ayacuchensis differs from *B. cebadilla* by having densely pilose culms near the base, adaxially pilose ligules 3–6.6 mm long, lower glumes 1-veined, upper glumes 3-veined, pilose lemmas (especially along the margins and near the apex), lemma margins that are tightly involute on lower 1/5–1/4, and lemma awns 3–5.5 mm long. The leaf blade of *B. ayacuchensis* (Fig. 4) is anatomically similar to the leaf blade of *B. catharticus* (the only taxon in sect. *Ceratochloa* for which anatomical data exist; Acedo & Llamas 1999). It has a well-developed keel, well-differentiated bulliform cells, and lower-order vascular bundles associated with sclerenchyma.

Morphological and molecular data also identify some differences between *B. ayacuchensis* and species classified in sect. *Ceratochloa*. *Bromus ayacuchensis* differs from taxa classified in sect. *Ceratochloa* by its 1- and 3- veined lower glumes. In the plastid trees, *B. ayacuchensis* is weakly supported as the sister group of a clade that comprises *Bromus* sect. *Ceratochloa* and *B. brachyanthera*, and these taxa are part of a larger clade that also includes species of sect. *Neobromus* (Fig. 1b). Among South American *Bromus*

species, 1- and 3-veined lower and upper glumes are found in taxa traditionally classified within *Bromus* sections *Bromopsis*, *Genea*, and *Neobromus* (Smith 1970). The two species classified in the closely-related sect. *Neobromus* are distinguished from *B. ayacuchensis* by their narrowly elliptic spikelets, lemmas with a deep apical sinus, and geniculate awns (Smith 1970; Matthei 1986). Species of sect. *Genea* in South America, which are all introduced, are easily separated from *B. ayacuchensis* by their oblong or wedge-shaped spikelets and narrow and elongate lemmas with long awns (Smith 1970). *Bromus* sect. *Bromopsis* is likely a paraphyletic assemblage of species (Saarela et al. in press) that have 1(–3)- and 3(–5)-veined lower and upper glumes, similar to *B. ayacuchensis*. The strongly laterally compressed spikelets and lemmas of *B. ayacuchensis* separate it from this artificial group of species, which have spikelets and lemmas that are terete and dorsally flattened or sometimes slightly keeled (Smith 1970), although the plastid and nuclear molecular data indicate that one species of sect. *Bromopsis* from South America, *B. brachyanthera*, is closely related to *B. ayacuchensis* and sect. *Ceratochloa* (Figs. 1a, b). The molecular data and mixed morphological characters suggest that *B. ayacuchensis* might have originated via hybridization between a species of sect. *Ceratochloa* and a species of the non-monophyletic sect. *Bromopsis*. Sampling of additional South American species of sect. *Bromopsis* will be necessary to determine if any are part of the clade that includes sects. *Neobromus*, *Ceratochloa*, *B. brachyanthera* and *B. ayacuchensis*.

Nine species of *Bromus* (*B. berteroanus* Colla; *B. catharticus*; *B. cebadilla*; *B. lanatus* Kunth; *B. modestus* Renvoize; *B. pitensis* Kunth; *B. segetum* Kunth; *B. striatus* Hitchc.; *B. villosissimus* Hitchc.) are currently known and verified by us from Peru (Planchuelo & Peterson 2000; Tovar 1993). *Bromus carinatus* Hook. & Arn. and *B. inermis* Leyss. have also been listed for Peru but these records are doubtful (Brako & Zarucchi 1994). *Bromus cebadilla* has been reported from the country previously without citation of specimens (Renvoize 1998; Pavlick et al. 2003). We provide confirmed records of this taxon in Appendix 1. *Bromus modestus* is a recently described species (Renvoize 1994), and we report additional collections from Peru in Appendix 1. We have also collected *B. coloratus* and *B. flexuosus* Planchuelo in Peru (Planchuelo 1983), and report these collections here for the first time (Appendix 1). With the discovery of *B. ayacuchensis*, and confirmed records of *B. coloratus* and *B. flexuosus*, the number of *Bromus* species known from Peru is 12. A new key to *Bromus* in Peru is provided below.

TAXONOMIC TREATMENT

Bromus ayacuchensis Saarela & P.M. Peterson, sp. nov. (**Fig. 2**). TYPE: PERU. DEPARTAMENTO AYACUCHO: Provincia Lucanas, 12 km E of Puquio on road towards Cuzco, (14°41'19.2" S Lat, 74°04'28.3" W Long), 3730 m, among large boulders with *Berberis* (Berberidaceae), above meadow with small creek, 11 Mar 2002, *P.M. Peterson 16452 & N.F. Refulio-Rodriguez* (HOLOTYPE: US!; ISOTYPES: K!, MO!, UBC!, USM!).

A *Bromo cebadilla* Steud. culmis pilosis basilaribus, adaxialibus pilosis 3–6.6 mm longis ligulis, inferioribus 1-nervatis glumis, superioribus 3-nervatis glumis, pilosis lemmatibus (praecipue apud margines et apicem), lemmatum marginibus inferioribus 1/5–1/4 involventibus, lemmatum aristis 3–5.5 mm longis, recedit.

Loosely caespitose perennials, rhizomes short with extravaginal shoot initiation. Culms (30–)50–120 cm tall, erect to slightly decumbent near base, pilose, densely pilose near base; internodes somewhat glabrous to sparsely pilose, retrorsely pilose just above dark brownish nodes. Sheaths 8–20 cm long, mostly longer than internodes below and shorter than internodes above, closed on lower 2/3–3/4, retrorsely pilose, hairs 0.7–1.6 mm long; margins smooth; cataphylls and lower sheaths densely pilose, often shredding. Ligules



FIG. 2. *Bromus ayacuchensis* (*Peterson 16452 & Refulio-Rodriguez*). **A.** Habit. **B.** Inflorescence. **C.** Sheath, ligule, and base of blade. **D.** Spikelet. **E.** Lower glume, dorsal view. **F.** Upper glume, dorsal view. **G.** Lemma, dorsal view. **H.** Floret, ventral view. **I.** Floret, lateral view. **J.** Base of floret with rachilla segment. **K.** Palea with lodicules and stamens, ventral view. **L.** Palea with rachilla segment and stamens, dorsal view. **M.** Lodicules, stamens, and pistil. **N.** Lodicules. **O.** Gynoecium, mature. **P.** Caryopsis.

3–6.6 mm long, membranous, pilose adaxially; apex obtuse, erose. Blades 20–55 cm long, 3–8 mm wide, flat, apically acuminate, mostly sparingly pilose below and glabrous to sparingly pilose above with hairs 0.5–1.2 mm long; margins scabrous. Panicles 12–25 cm long, 1–8 cm wide, obovate, lax, often nodding; central axis glabrous or with an occasional hair; branches mostly 1.5–10 cm long, ascending or appressed to spreading and drooping, naked near base, often re-branched immediately at base, scabrous, hairs antrorse and stiff; lower inflorescence nodes usually with 2–4 branches. Spikelets (12–)18–27 mm long, florets 5–8, laterally compressed; lowest rachilla internodes 2–3 mm long. Glumes 5–11.2 mm long, glabrous or sparsely hairy; apex entire or mucronate, the mucro usually ≤ 1 mm long; lower glumes 5–8 mm long, 1-veined, apex acuminate; upper glumes 8–11.2 mm long, 3-veined, apex acute. Lemmas 10–12.6 mm long, chartaceous, 5- or 7-veined, pilose, especially along margins and near apex, hairs 0.2–0.5 mm long; margins tightly involute on lower 1/5–1/4; apex entire or minutely bifid, teeth ≤ 0.2 mm long, awned, awn 3–5.5 mm long, straight. Paleas 9–12 mm long, shorter than lemma, membranous to hyaline, ciliate along keel, glabrous between veins; apex acuminate, sometimes mucronate, veins extending as mucro usually ≤ 1 mm long. Lodicules 1–1.3 mm long, narrowly elliptic to narrowly obovate, unlobed. Stamens 3; anthers 3.1–3.8 mm long, yellowish-orange. Ovaries 1.2–2 mm long, golden brown, hairy on upper 1/2–2/3 with hairs 0.3–0.6 mm long; styles 2, separate; stigmas 2, feathery, whitish. Caryopses 5.8–7 mm long, yellowish-brown, apex hairy, hairs 0.4–0.8 mm long; hilum extending length of grain.

Distribution and Habitat.—Known only from near the type locality 12–15 km E of Puquio on road towards Cuzco between 3730–3790 m on slopes under large boulders and beneath thorny shrubs, such as *Colletia spinosissima* J.F. Gmel. (Rhamnaceae), *Berberis* (Berberidaceae), and *Ribes* (Grossulariaceae); also associated with *Lepidophyllum* (Asteraceae) and *Festuca* (Poaceae). Suitable habitat for *B. ayacuchensis* is estimated to be 5 km^2 at the type locality (Fig. 3).

Etymology.—The epithet 'ayacuchensis' is designated to reflect the known distribution of the new species in Departamento Ayacucho, Peru.

Additional Specimens Examined: **PERU: Departamento Ayacucho:** Provincia Lucanas, 13 km E of Puquio at km 172 marker (14°41'18.5" S Lat, 74°04'26.8"W Long), 8 Apr 2004, *P.M. Peterson & N.F. Refulio-Rodríguez 18212* (K, MO, UBC, US, USM); 15 km E of Puquio at Km 174 Marker (14° 41' 42.9"S Lat, 74°03'46.8" W Long), 9 Apr 2004, *P.M. Peterson & N.F. Refulio-Rodríguez 18233* (K, MO, UBC, US, USM).

Leaf Anatomy.—The blades (Fig. 4) are flat and have a C_3 anatomy, with completely sclerefied margins. The epidermis is comprised of oval to round, subequal cells. Bulliform cells are 2–4 times the size of the regular epidermal cells, located adaxially, and arranged in groups of 5–6. Stomates are located adaxially and abaxially, and are usually associated with deep sunken pits. The chlorenchyma tissue is of the festucoid type. Vascular bundles are all primary, round in outline, and they are all approximately the same size, with the exception of the larger central rib. Vascular bundles are well differentiated into xylem adaxially and phloem abaxially. Vascular sheaths are double; the inner sheath is sclerenchymatous and complete, whereas the outer sheath is parenchymatous and incomplete. Sclerenchyma fibers are associated adaxially with all bundles, and abaxially with all bundles except those towards the margins of the blade; intercostal sclerenchyma absent. The central structure of the blade is well differentiated, and includes a vascular bundle and a prominent keel comprised of sclerenchyma.

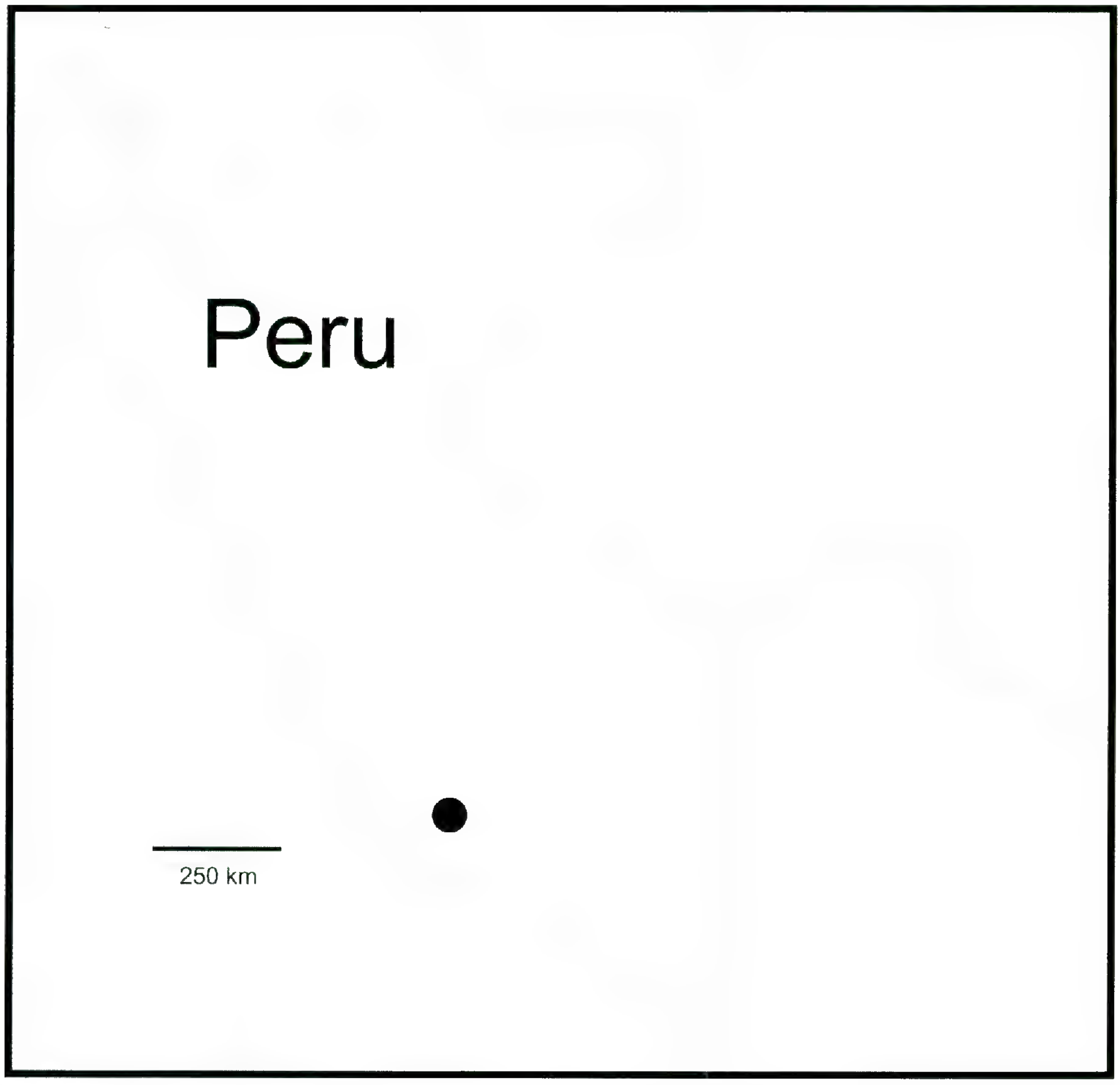


Fig. 3. Geographical distribution of *Bromus ayacuchensis*.

KEY TO THE SPECIES OF *BROMUS* IN PERU

1. Lemma awns geniculate and twisted; plants short-lived annuals (sect. **Neobromus**) _____ **B. berteroanus**
1. Lemma awns straight and not twisted; plants short-lived to long-lived annuals, biennials, or perennials.
2. Spikelets generally laterally compressed; lemmas laterally compressed and keeled (sect. *Ceratochloa*).
3. Mature anthers 3–5.5 mm long.
4. Lower glumes 1-veined; upper glumes 3-veined; culms densely pilose below; ligules adaxially pilose, 3–6.6 mm long; lemmas pilose, especially along the margins and near the apex _____ **B. ayacuchensis**
4. Lower glumes 5-veined; upper glumes 7–9-veined; culms glabrous or pubescent below; ligules adaxially glabrous, 2–3 mm long; lemmas glabrous or scabrous throughout _____ **B. cebadilla**
3. Mature anthers 0.5–2 mm long.
5. Lemma awns 12–18(–25) cm long; plants short-lived annuals found only along the coastal desert of Arequipa; panicle branches nodding, drooping and flexuous _____ **B. striatus**
5. Lemma awns 0.5–6 mm long; plants long-lived annuals, biennials, or perennials, plants

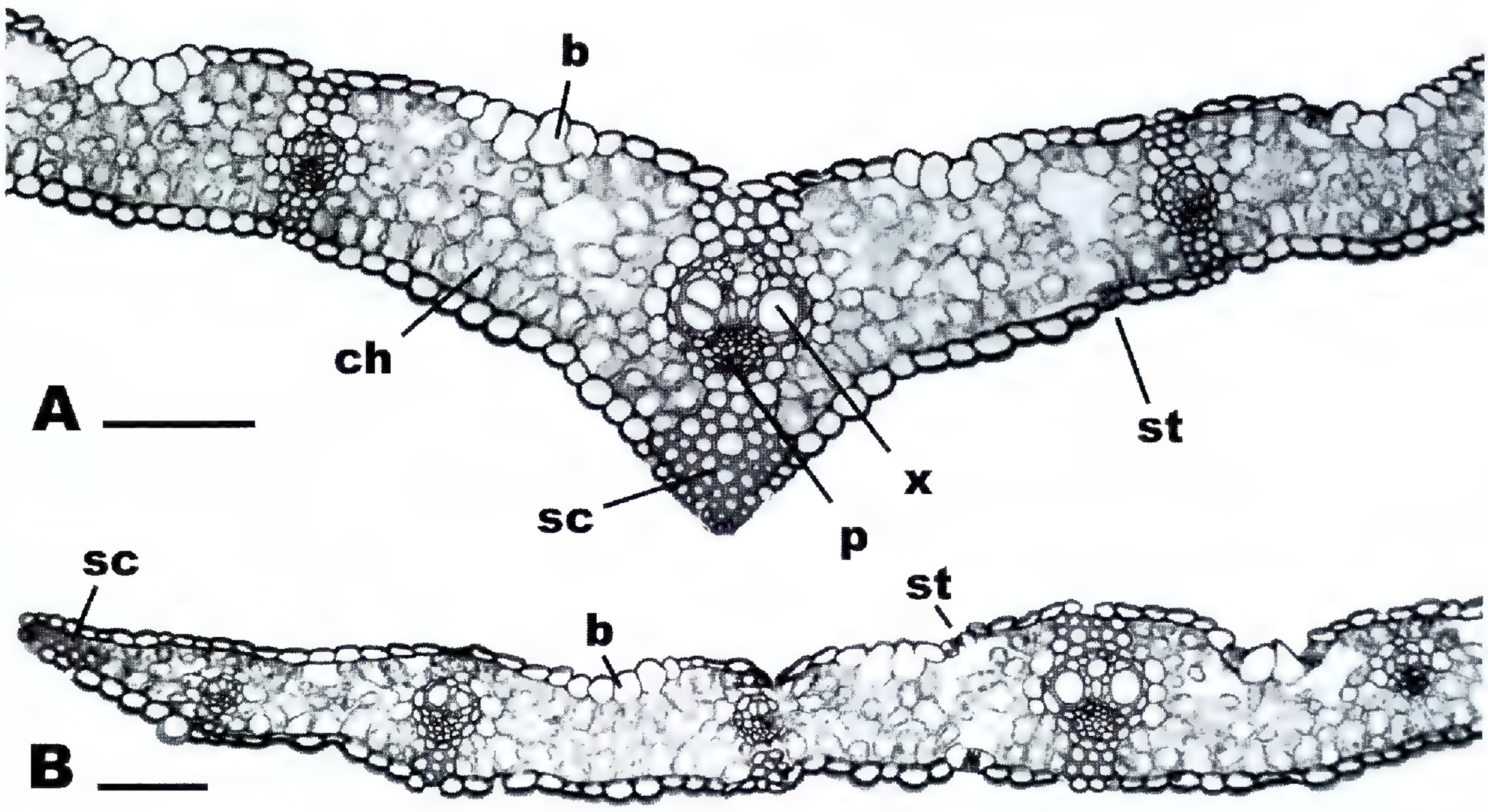


FIG. 4. Leaf anatomy of *Bromus ayacuchensis* [*Peterson 18212 & Refulio-Rodríguez* (US)]. Transverse section of: **A.** center of leaf blade (scale bar = 150 μm); **B.** margin of leaf blade (scale bar = 75 μm). Symbols as follows: **b** = bulliform cells; **ch** = chlorenchyma tissue; **p** = phloem tissue; **sc** = sclerenchyma tissue; **st** = stomata; **x** = xylem tissue.

more wide-ranging; panicle branches usually stiffly erect and ascending, rarely nodding, drooping, or flexuous.

6. Lower glumes 5–7(–9)-veined; upper glumes generally 7–9-veined; spikelets strongly laterally compressed _____ **B. catharticus**
6. Lower glumes 3-veined; upper glumes 5-veined; spikelets not strongly laterally compressed _____ **B. coloratus**

2. Spikelets terete or dorsally flattened; lemmas terete or dorsally flattened (sect. **Bromopsis**).
   7. Culms 5 ·30(–40) cm tall; leaf blades generally 1–2.5 mm wide.
      8. Spikelets densely villose; panicles 1–3.5 cm long, contracted with short, stiff branches; lemmas hairy _____ **B. villosissimus**
      8. Spikelets glabrous, scabrous or pilose; panicles 3–8 cm long, open with long, flexuous branches; lemmas glabrous _____ **B. modestus**
   7. Culms (15–)30–120 cm tall; leaf blades generally 2–12 mm wide.
      9. Lemma awns (4–)5–9 mm long; lower glumes 0.8–1 mm wide near base.
         10. Pedicels flexuous, erect and reflexed; glumes hairy; pedicels hairy _____ **B. flexuosus**
         10. Pedicels straight and erect spreading; glumes glabrous; pedicels glabrous _____ **B. segetum**
      9. Lemma awns 1–5(–6) mm long: lower glumes 1–3 mm wide near base.
         11. Lower glumes 1–1.2 mm wide near base; pedicels hairy; lemmas villous _____ **B. lanatus**
         11. Lower glumes 2.2–3 mm wide near base; pedicels glabrous to short pubescent; lemmas glabrous to pubescent, sometimes villous along the margins _____ **B. pitensis**

APPENDIX 1

Citation of new records and confirmed reports of *Bromus* in Peru.

Bromus cebadilla Steud.—**Cajamarca:** San Miguel: 61 km N of Cajamarca on highway 3N towards Bambamarca, 3640 m, 16 Mar 2000, *P.M. Peterson 14914 & N.F. Refulio-Rodríguez* (ACOR, US, USM).

Bromus coloratus Steud.—**Arequipa. Caravelí:** 5 km S of Airoca and 3 km N of Cahuacho, 15°28′10.3"S, 73°29′26.6"W, 3520 m, 3 Mar 2002, *P.M. Peterson 16390 & M.I. LaTorre, A. Ramírez & D. Susanibar* (ACOR, US, USM). **Apurimac. Aymaraes:** 9 km SW of Cotaruse on road towards Puquio, 3510 m, 14°29′30.8"S, 73°15′04.2"W, 13 Mar 2002, *P.M. Peterson 16480 & N.F. Refulio-Rodríguez* (ACOR, US, USM). **Ayacucho. Lucanas:** 6 km E of Puquio on

road towards Chaviña, 14°41'43.9"S, 74°05'35.4"W, 3274 m, 27 Feb 2002, *P.M. Peterson 16296 & M.I. LaTorre, A. Ramírez & D. Susanibar* (ACOR, US, USM). **Junín. Junín:** 2 km SW of San Jose on road towards Junín, 3970 m, 8 Apr 1997, *P.M. Peterson 14121 & N.F. Refulio-Rodríguez* (ACOR, USM).

Bromus flexuous Planchuelo.—**Cuzco. Calca:** 22 km N of Calca on road towards Lares, 4120 m, 13°12'56.6"S, 71°54'35.2"W, 16 Mar 2002, *P.M. Peterson 16556 & N.F. Refulio-Rodríguez* (ACOR, US, USM).

Bromus modestus Renvoize.—**Arequipa:** Sumbay, 4000 m, *A. Weberbauer 6902* (F, US). **Huancavelica. Huancavelica:** Tansiri near Manta, 4400–4500 m, 4 Apr 1953, *O. Tovar 1181* (US, USM). **Ayacucho. Lucanas:** 25 km SE of Puquio on road towards Chaviña, 14°45'17.0"S, 74°03'02.6"W, 3850 m, 27 Feb 2002, *P.M. Peterson 16302 & M.I. LaTorre, A. Ramírez & D. Susanibar* (US). **Cuzco. Calca:** 30 km N of Claca just below Abra de Amparaes, 13°10'40.2"S, 71°54'09.2"W, 4530 m, 15 Mar 2002, *P.M. Peterson 16562 & N.F. Refulio- Rodríguez* (ACOR, US, USM). **Puno. Chucuito:** 20 Km E of Huacullani on road towards Desaguadero, 3880 m, 5 Mar 1999, *P.M. Peterson 14636 & N.F. Refulio-Rodríguez, F. Salvador-Perez* (ACOR, US, USM).

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PSIDIUM CAULIFLORUM (MYRTACEAE), A NEW SPECIES FROM BAHIA, BRAZIL

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ABSTRACT

Psidium cauliflorum, from the Brazilian state of Bahia, is described and illustrated. It differs from all other species of *Psidium* in having its flowers borne in clusters on older branches and trunks. It may belong to a complex of species including *P. oligospermum, P. sartorianum, P. glaziovianum, P. schenckianum*, and perhaps *P. appendiculatum*.

RESUMO

Psidium cauliflorum, uma nova espécie do estado da Bahia, Brasil, é descrita e ilustrada. Essa espécie, distinta das demais do gênero pelas inflorescências aglomeradas em ramos velhos e troncos, é possivelmente relacionada ao complexo que inclui *P. oligospermum, P. sartorianum, P. glaziovianum, P. schenckianum*, e talvez *P. appendiculatum*.

Psidium L. (Myrtaceae) is a genus of at least 50 and perhaps as many as 100 species (McVaugh 1968) with a natural range from Mexico and the Caribbean to Uruguay and northern Argentina on the American continents and extending to some east Pacific islands (e.g., Galapagos). *Psidium* is distinguished from other genera by a combination of floral and seed characters discussed in Landrum and Sharp (1989) and Landrum (2003). *Psidium cauliflorum* appears to belong to a group of species including *P. oligospermum* DC., *P. sartorianum* (O. Berg) Niedenzu, *P. glaziovianum* Kiaerskou, *P. schenckianum* Kiaerskou, and perhaps *P. appendiculatum* Kiaerskou. These species have brochidodromous leaf venation with dendritic tertiaries. The calyx is generally closed or nearly closed in the flower bud and they often have wart-like to flange-like apical appendages on the calyx (but this character is not present in *P. cauliflorum*). The seeds are 3–6 mm long with rounded edges and few (5–12) per fruit. Ovules are usually less than 30 per locule. The limits between widespread and variable *P. sartorianum* and *P. oligospermum*, which is restricted to Bahia, are still problematic and require more study. We believe that *Psidium oligospermum* and *P. schenckianum* frequently hybridize based on herbarium specimens and field observations. All of these species (except perhaps *P. sartorianum*) grow in Bahia and are sometimes endemic to that state.

Psidium cauliflorum Landrum & Sobral, sp. nov. (**Fig. 1**). TYPE: BRAZIL. BAHIA: mun. Cachoeira, Morro Belo, Vale dos Rios Paraguaçu e Jacuipe, 39°05'W, 12°32'S, 40–100 m, Dec 1980 (fl), *Grupo Pedra do Cavalo 955* (HOLOTYPE: HRB, =ASU, BHCB photos; ISOTYPES: ALCB (2 sheets),= ASU, BHCB photos, RB).

Haec species *Psidio sartoriano* primo aspectu similis, flores fasciculati, cauliflori differt. Arbor 3–5.5-metralis; folia elliptica, vel ovalia, 2.7–6.8 × 1–3 cm, 1.8–2.6 plo longiora quam latiora; peduculo 1 9 mm; calyx ante anthesin clausus, sub anthesi irregulariter fissus.

Tree 3–5.5 m high, sparsely to densely pubescent on young growth; hairs rusty brown to whitish, mostly erect or spreading, up to ca. 1 mm long; young twigs terete to slightly compressed, densely to moderately pubescent, the bark reddish brown to gray, the older

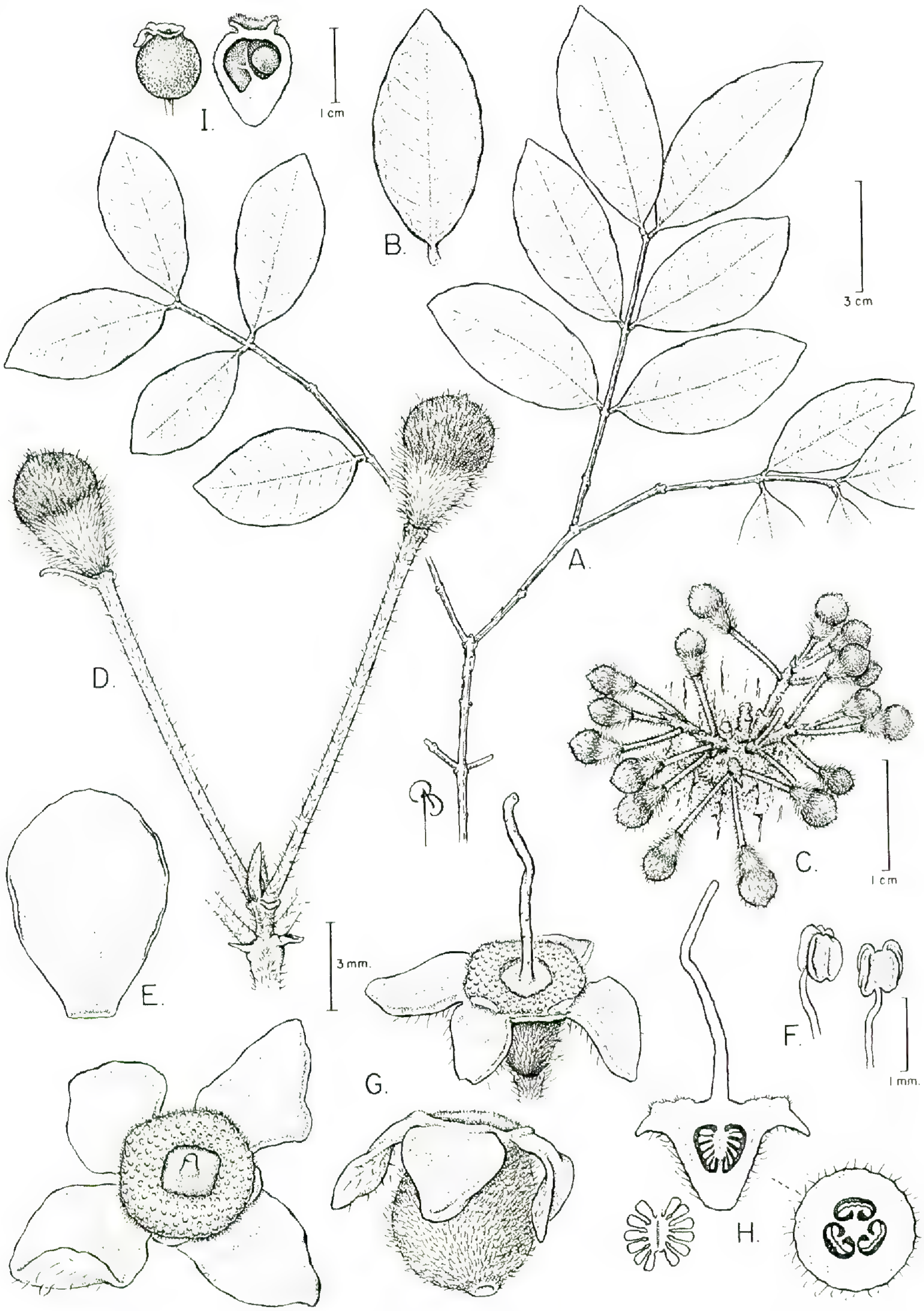


FIG. 1. A–B, *Psidium cauliflorum*. **A.** young branch and leaves. **B.** upper surface of single leaf. **C.** cauliflorous inflorescence. **D.** portion of inflorescence with two closed buds. **E.** detached petal. **F.** anthers. **G.** remnants of flowers and young fruit after stamens and petals have fallen. **H.** dissected ovary showing ovary locules, placentation, and uniseriate ovules. **I.** fruit and single seed. (A & I, *Grupo Pedra do Cavalo 326*, ALCB; C, *Grupo Pedra do Cavalo 955*, HRB, the holotype; D–H, *Queiroz et al. 1742*, ASU). Drawn by Bobbi Angell.

twigs gray, glabrous, the bark somewhat flaky. **Leaves** elliptic to oval, 2.7–6.8 cm long, 1–3 cm wide, 1.8–2.6 times as long as wide, moderately to sparsely puberulent (or more densely so along midvein), glabrescent with age; apex acute; base rounded to cuneate; petiole channeled, densely to sparsely pubescent to glabrescent, 2–3 mm long, 0.5–1 mm wide; midvein impressed proximally to nearly flat distally above, prominent below, the venation brochidodromous, the lateral veins slightly raised and visible above or obscure, 6–9 pairs leaving midvein at an angle of ca. 45 degrees, the marginal vein arching between laterals, equalling them in prominence, running ca. 1–1.5(–3) mm from margin, the tertiary veins forming a dendritic pattern that arises from the marginal vein, scarcely to clearly visible; blades subcoriaceous, drying reddish brown to grayish, densely glandular beneath. **Flower buds** pyriform, 4–6 mm long, densely pubescent on hypanthium, sparsely so on calyx, borne on older stems in clusters of as many as 20, apparently appearing at the same point season after season; peduncles uniflorous to triflorous, 1–9 mm long, ca. 0.6 mm wide, sparsely to densely pubescent, sometimes borne on short bracteate shoots, the branches of dichasia ca. 3 mm long; bracteoles linear to narrowly lanceolate, ca. 1–1.5 mm long, caducous before anthesis; calyx closed except for an apical pore, with hairs sometimes protruding from pore, tearing irregularly at anthesis; petals obovate to suborbicular, ca. 7 mm long, glabrous or with cilate margins; hypanthium obconic, 2–3 mm long; disk ca. 3.5 mm across at anthesis (5 mm in fruit), pubescent; stamens ca. 6 mm long, 150–190; anthers ca. 0.3 mm long, with a terminal gland and usually 2 other glands in the connective; style ca. 8 mm long, glabrous; ovary 3-locular; ovules 7–20 per locule, uniseriate on each lamella of a slightly peltate placenta. **Fruit** 1–2 cm in diam.; seeds few, ca. 6 mm long.

Only five collections have been made of *Psidium cauliflorum* so little is known of this very distinctive, but rare species. It has been collected flowering in June, July, October, and December and probably fruits shortly afterward as is normally the case in *Psidium*. De Queiroz et al. report that it grows in "floresta estacional," that is, temporarily deciduous dry forests.

PARATYPES: BRAZIL. BAHIA: mun. Cachoeira, Estaçao da Mata, Vale dos Rios Paraguaçu e Jacuipe, 39°05'W, 12°32'S, 40–120 m, Jul 1980 (fl, fr), *Grupo Pedra do Cavalo 407* (ALCB), Jun 1980 (fl, fr), *Grupo Pedra do Cavalo 326* (ALCB), Oct 1980 (fl), *Grupo Pedra do Cavalo 814* (ALCB, CEPEC); mun. Feira de Santana, 11 km NW de Jaguara, Fazenda Monte Verde, floresta estacional, 320 m, 21 Jul 1987 (fl), *L. P. de Queiroz, Lemos & Lôbo 1742* (ASU).

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Book Review

Charles Ainsworth (Ed.). 2006. **Annual Plant Reviews, Volume 20: Flowering and Its Manipulation.** (ISBN 1-4051-2808-9, hbk.). Blackwell Publishing, 9600 Garsington Road, Oxford OX4 2DQ, U.K. (**Orders:** www.blackwellpublishing.com, 1-800-862-6657). $199.99, 304 pp., 6 1/4" × 9 1/2".

An astonishing variety of flowering plants currently dominate the plant life of our planet. The editor of *Flowering and Its Manipulation*, Charles Ainsworth, writes in the preface "...there are good reasons for supposing that the flower itself has been a major contributing factor to the spread of the Angiosperms." Therefore, the study of angiosperm flowering is an important field. This genetics-heavy volume from the *Annual Plant Reviews* series is designed to complement an earlier edition- *Volume 6: Plant Reproduction*. The chapters of the book are laid out in a logical order that parallels the birth, development, and death of the flower. The first chapter is devoted to a discussion of the origin and evolution of the flower through a genetic model. Chapter 2 focuses on the study of floral induction, or the factors that cause plants to flower at certain moments in time. The goal of Chapter 3 is to "outline the present state of knowledge of on the function, regulation, and conservation of the genes that participate in the ABC program...", the central model of floral development. The complex genetic processes that underlie the beguilingly simple ABC model are clearly elucidated. In chapter 4, the "genetic control of flower size and shape" is discussed in detail. The next chapter focuses on genetics and development of floral architecture, described as "...the shoot system that gives rise to flowers..." The second part of the book includes three chapters focused on "specialized components of floral development." Chapter 6 focuses on the complex patterns of male and female flowers in monoecious plants, with a focus on the well-studied cucumber and maize plants. Chapter 7 focuses on the genetics of cytoplasmic male sterility. The diversity and significance of perennials is the focus of Chapter 8, which provides "a sketch map of the types of perennial flowering." The next two chapters are devoted to the most celebrated floral aspects- color and scent. Chapter 9 details recent developments in our understanding of the biochemistry and molecular biology of flower color. The subsequent chapter describes the biochemistry, physiology, genetics, and regulation of floral scent. Both chapters contain details on the use of genetic engineering to manipulate floral color and scent. The final chapter is "appropriately" focused on floral senescence, according to the editor. Floral senescence, or the "death" of flowers, is discussed in detail, as well as methods used to manipulate senescence and useful applications for the floral industry.—*Marissa Oppel, MS, Collections and Research Assistant, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

NEW SPECIES OF MYRTACEAE FROM ECUADOR AND PERU

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ABSTRACT

Two new species of Myrtaceae from Ecuador and Peru are described and illustrated: **Calyptranthes manuensis** and **Eugenia yasuniana**.

RESUMEN

Se describen y se ilustran dos especies nuevas de Myrtaceae del Ecuador y Peru: **Calyptranthes manuensis** y **Eugenia yasuniana**.

INTRODUCTION

In preparation for the treatment of Myrtaceae for the Flora of Ecuador and adding to the checklist of species for the country (Holst 1999), two new species are described in this paper: *Calyptranthes manuensis* and *Eugenia yasuniana.*

Calyptranthes manuensis B. Holst & M.L. Kawasaki, sp. nov. (**Figs. 1A–G**). TYPE: PERU. MADRE DE DIOS: Manu, Parque Nacional del Manu, Río Manu, Cocha Cashu Station, 350 m, 8 Oct 1980 (fl), *R. Foster 5501* (HOLOTYPE: F; ISOTYPE: SEL).

Ab omnibus speciebus generis characteribus combinatis differt: inflorescentiis reductis, alabastris oblongis, subsessilibus, follis nervo medio supra biconvexo.

Shrubs or small trees 1–10 m high, mostly glabrous except for the sericeous young vegetative growth, trichomes dibrachiate, yellowish-brown; branchlets terete, often with 1 or 2 pairs of narrowly elliptic, navicular bracts, 1–2.5 × 0.2–0.4 cm. Young leaves drooping, reddish; **leaf blades** narrowly to broadly elliptic to narrowly obovate, 14–18 × (3–)5–8 cm, chartaceous, thinly sericeous when very young on lower surface, becoming mostly glabrous, drying brownish-green, paler below; apex abruptly acuminate, the acumen to ca. 1 cm long; base cuneate to obtuse; midvein biconvex above, convex below; lateral veins 20–25 pairs, slender, inconspicuous, slightly convex on both surfaces; marginal veins 2, the innermost 2–3 mm from blade margin, similar to the lateral veins; glands numerous, light-brown, salient on both surfaces; petiole 0.5–1.2 cm long, flattened, glabrous. **Inflorescences** paired, greatly abbreviated, 2-flowered spikes borne at the nodes of the fallen bracts, ca. 1.5–2 cm long, the main axis 2–3 mm long, densely sericeous to glabrous, the pedicels 0–5 mm long, stout when present. **Flower buds** oblong, 8–10 mm long, gland-dotted; bracteoles subulate, ca. 2 mm long, early deciduous; calyx calyptrate, puberulous to glabrous, acuminate, deciduous; petals absent; stamens numerous, the filaments ca. 4–5 mm long, the anthers ca. 0.5 mm long; style ca. 6 mm long, the stigma capitate; hypanthium prolonged ca. 3–4 mm beyond the ovary, the upper portion explanate at anthesis, densely puberulous basally to glabrous without; disk ca. 3 mm diam.; ovary 2-locular, with 2 ovules per locule. **Fruits** globose, 2–3 cm diam., crowned by a circular hypanthium scar, gland-dotted, glabrous, dark-purple to black; seeds 1 or 2, ca. 9 × 7 mm, the seed coat membranous; embryo myrcioid, the cotyledons leafy and folded, the radicle well developed, equaling cotyledons in length.

Distribution.—This species, first known from Amazonian Peru (Parque Nacional del

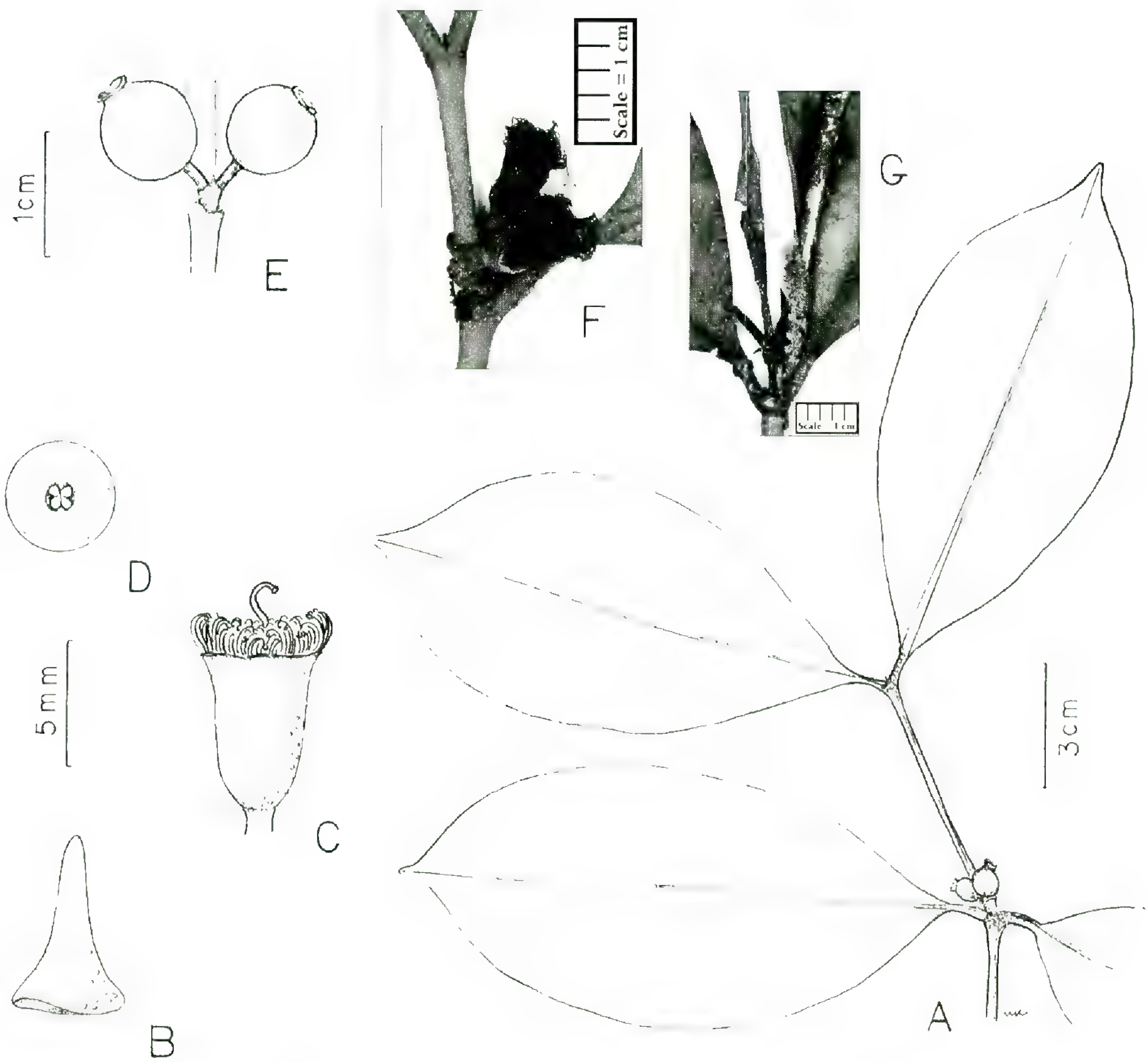


Fig. 1. ***Calyptranthes manuensis*** **B. Holst & M.L. Kawasaki. A. Leaves and young fruits. B. Calyptra. C. Flower. D. Transverse section of ovary. E. Fruits. F. Detail of inflorescence. G. Detail of branchlet with navicular bracts. (A,** ***Foster et al. 7186*****; B–D, F,** ***Foster 5501*****; E,** ***Foster & Terborgh 5244*****; G,** ***Croat 72503*****).**

Manu in Madre de Dios), was later collected in Ecuador; it occurs in lowland humid (floodplain) forests, at 320–350 m elevation.

Calyptranthes manuensis is characterized by the much reduced inflorescences, subsessile to short-pedicellate, oblong flower buds, and leaves with biconvex midvein.

Additional collections examined: **ECUADOR. Napo:** Jatun Sacha, Rio Napo, at mouth of Rio Huambuno, 3 km downstream from Campana Cocha, primary forest on river floodplain, 00°55'S, 77°25'W, 350 m, 29 Jun 1987 (fr), *D. Neill, W. Wilbert & SFS Students 7742* (MO, SEL). **Pastaza:** Vía Auca, 115 km S of Coca, ca. of Río Tigüino, road PETRO-CANADA in construction, 01°15'S, 76°55'W, 320 m, 24 May 1989 (fr), *D. Rubio133* (F, MO, SEL); Vía Auca, 115 km S of Coca, ca. of Río Tigüino, road PETRO-CANADA in construction, 01°15'S, 76°55'W, 320 m, 24 May 1989 (fr), *D. Rubio 153* (F, MO, SEL); Vía Auca, 110 km S of Coca, 10 km from Rio Tigüino, Sector Cristal, 01°15'S, 76°55'W, 320 m, 7 Jan 1989 (fr), *W. Palacios, C. Iguago & F. Hurtado 3361* (F, MO, SEL). **Sucumbios:** Lago Agrio, along road between Lago Agrio (Nueva Loja) and Coca (Pto. Francisco de Orellana); 26 km S of Lago Agrio, 4.6 km S of El Emo, then 2.8 km W of main Lago Agrio-Coca Road, along farm road, 00°05'S, 76°54'W, 355 m, 29 Feb 1992 (fr), *T. Croat 72503* (MO, SEL). **PERU. Madre de Dios:** Manu, Parque Nacional del Manu, Río Manu, vicinity of Cocha Cashu Station, 5 Nov 1976 (fl), *R. Foster & J. Terborgh 5189* (F); Manu, Parque Nacional del Manu, Río Manu, vicinity of Cocha Cashu Station, 27 Nov 1976 (fr), *R. Foster & J. Terborgh 5244* (F); Manu, Parque Nacional del Manu, Río Manu, vicinity of Cocha Cashu Station, 22 Apr 1977 (fr), *R. Foster & C. Janson 6279* (F); Manu, Parque Nacional del Manu, Río Manu, Cocha Cashu Station, 22 Oct 1979 (y fr), *R. Foster 7186* (F); Manu, Parque Nacional del Manu,

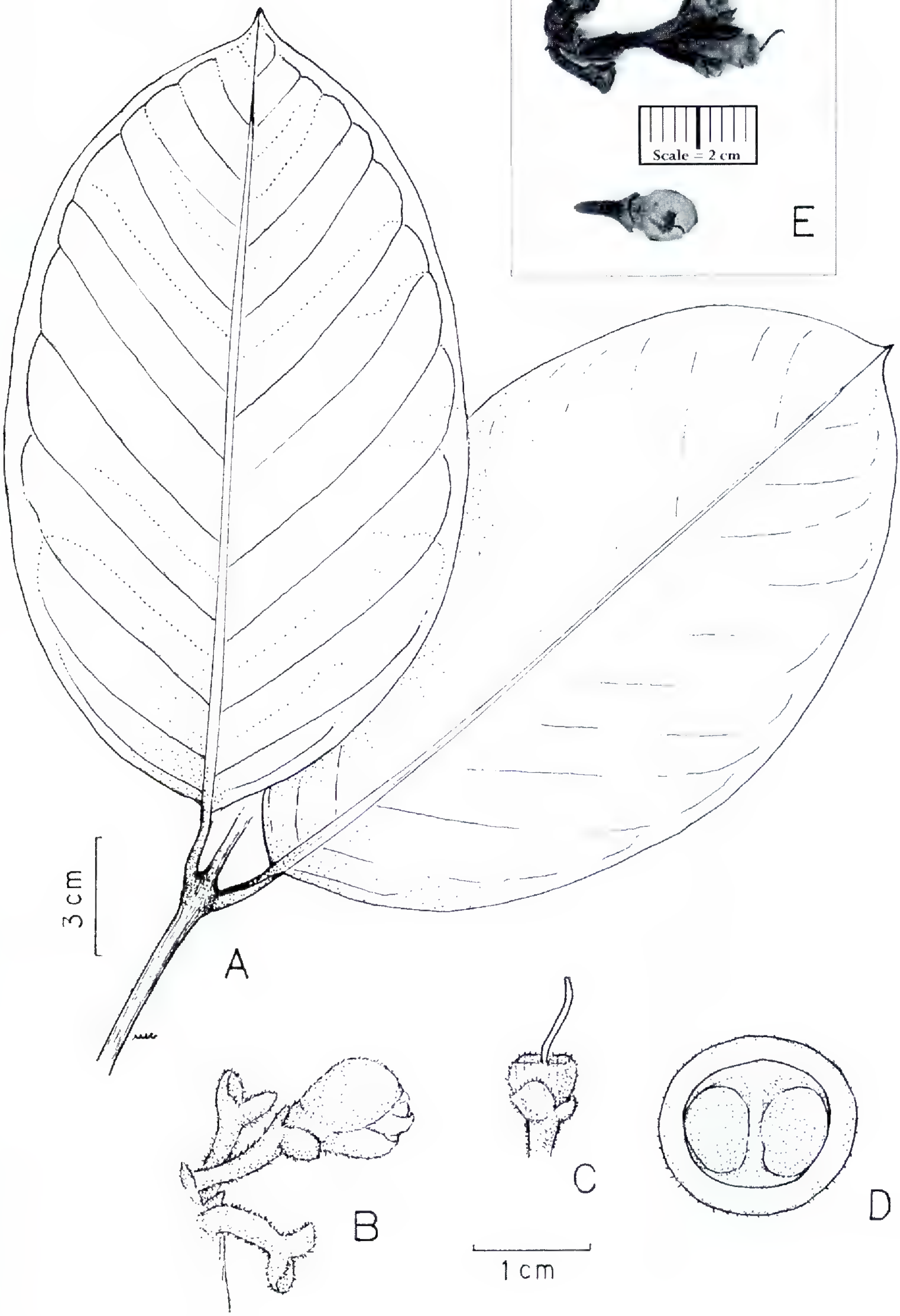


FIG. 2. *Eugenia yasuniana* B. Holst & M.L. Kawasaki. **A.** Leaves. **B.** Inflorescence. **C.** Flower after stamens and calyx-lobes have fallen. **D.** Medial section of fruit. **E.** Inflorescence and flower. (A–C, E, *Romoleroux 2021*; D, *Villa & Vélez 852*).

Río Manu, Cocha Cashu Station, 4 May 1981 (fr), *R. Foster & C. Janson 8385* (F); Manu, Parque Nacional del Manu, Río Manu, Cocha Cashu Station, 11°50'S, 71°25'W, 350 m, 11 Jul 1984 (fr), *R. Foster 9613* (F, MO).

Eugenia yasuniana B. Holst & M.L. Kawasaki, sp. nov. (**Figs. 2A–E**). TYPE: ECUADOR. ORELLANA ("NAPO" on label): Estación Científica Yasuní, Tiputini River, NW of confluence with Tivacuno River; 6 km E of main Maxus Road, Km 44, on spur road toTivacuno oilwell, near 50 ha plot, sendero Norte, 00°38'S, 76°30'W, 200–300 m, 21 Nov 1995 (fl), *K. Romoleroux & R. Foster 2021* (HOLOTYPE: QCA; ISOTYPES: F, SEL).

Maxime affinis *Eugenia myrobalanae* DC. sed diversa: folliis lamina subtus sericea (nec puberula), nervo marginali praesenti (nec absenti), pedicellis brevioribus, calycis lobis deciduis (nec persistentibus) et fructibus globosis (nec ellipsoideis).

Trees 10–12 m high, the trichomes simple, yellowish-brown to yellowish on leaves, reddish-brown to yellowish-brown on inflorescences; branchlets slightly compressed in cross section. **Leaf blades** narrowly elliptic to elliptic, 15.5–23 3 7.5–14 cm, coriaceous, the upper surface puberulous to glabrous, drying brownish-green to dark-brown, the lower surface paler, densely sericeous-pubescent, glabrescent; apex abruptly acuminate, the acumen to ca. 1 cm long; base cuneate to obtuse; midvein narrowly convex, in a channel, appearing sulcate above, convex below; lateral veins 10–13 pairs, impressed to slightly convex above, convex below, arcuate-ascending, the arches forming a marginal vein to 5 mm from blade margin; glands indistinct to numerous, punctiform, dark-brown, plane to convex above, indistinct below; petiole ca. 2 cm long, channeled, puberulous to glabrous. **Inflorescences** racemose, sometimes shortly so and appearing fasciculate, borne on leafless branches, with up to ca. 8 flowers, the main axis to 4 cm long, the pedicels to 1 cm long, appressed-pubescent. **Flowers** 4-merous; buds subglobose, ca. 1.5 cm long; bracts and bracteoles suborbicular, ca. 3 mm long, persistent; calyx-lobes ovate to broadly ovate, ca. 1 cm long, obtuse, sericeous-pubescent without, deciduous; petals elliptic, ca. 1 cm long; stamens numerous, the filaments ca. 6 mm long, the anthers ca. 1.2 mm long; style ca. 7 mm long, the stigma punctiform; hypanthium not prolonged beyond the ovary, appressed-pubescent without; disk ca. 4–5 mm diam., pubescent; ovary 2-locular, with several ovules per locule. **Fruits** globose, ca. 3–4 cm diam., appressed-puberulous, yellow; seeds 1–2, ca. 2.5 3 1.5 cm long, the seed coat membranous; embryo eugenioid, the cotyledons fleshy, connate, the radicle indistinct.

Distribution.—Known only from Ecuador, in lowland forests of the Estación Científica Yasuní (Orellana), at 200–300 m elevation.

Eugenia yasuniana is related to *E. myrobalana* DC., a species from Amazonian Peru and Brazil, but differs by the leaves being densely sericeous-pubescent below, with a marginal vein (vs. leaves puberulous below, marginal vein absent), pedicels to 1 cm long (vs. 1.2–2.5 cm long), deciduous (vs. persistent) calyx-lobes, and globose (vs. ellipsoid) fruits.

Additional collections examined: **ECUADOR. Orellana:** Estación Científica Yasuní, Tiputini River, NW of confluence with Tivacuno River, 6 km E of main Maxus Road, Km 44, on spur road toTivacuno oilwell, 50 ha plot, sendero Saino, 00°59'S, 77°45'W, 200–300 m, 6 Feb 1999 (fr), *K. Romoleroux, G. Villa & L. Vélez 3210* (F, QCA); Estación Científica Yasuní, Tiputini River, NW of confluence with Tivacuno River, 6 km E of Repsol-YPF Road, Km 7, on spur road to oilwell, 00°38'S, 76°30'W, 200–300 m, 29 Jan 2001 (fr), *G. Villa & L. Vélez 852* (F, QCA).

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ZEUXINE PANTLINGII, SP. NOV. (ORCHIDACEAE), A NEW SPECIES FROM INDIA

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ABSTRACT

A new species of *Zeuxine* Lindl., **Zeuxine pantlingii** Av. Bhattacharjee & H.J. Chowdhery closely allied to *Z. goodyeroides* Lindl. is described from West Bengal, India. A brief life sketch and a portrait of Robert Pantling after whom the species is named is also provided.

KEY WORDS: Orchidaceae, New species, *Zeuxine pantlingii*, West Bengal, India

RESUMEN

Se describe una nueva especie de West Bengal, India de *Zeuxine* Lindl., **Zeuxine pantlingii** Av. Bhattacharjee & H.J. Chowdhery fuertemente relacionada con *Z. goodyeroides* Lindl. Se aporta también un breve resumen de la vida y un retrato de Robert Pantling a quien se dedica la especie.

Dressler (1993) placed the genus *Zeuxine* Lindl. in the subtribe *Goodyerinae* Klotzsch under the tribe Cranichideae Endlicher of the subfamily Spiranthoideae Dressler. It is represented by about 70 species (Pearce & Cribb 2002) widely distributed from tropical Africa, Madagascar through India, Sri Lanka and to the Pacific Islands while, 16 species are known from India (Singh et al. 2002). During a recent plant collection trip to North Bengal in connection with the revisionary studies of the family Orchidaceae for *Flora of India* project of Botanical Survey of India, the authors came across an interesting specimen of *Zeuxine* Lindl. A critical study of the literature and herbarium material revealed it to be a hitherto unknown species of the genus *Zeuxine*, which is described and illustrated here.

Zeuxine pantlingii Av. Bhattacharjee & H.J. Chowdhery, sp. nov. (**Figs. 1–3**). TYPE: INDIA. WEST BENGAL: Darjeeling District, near Mongpoo, ca. 900 m, 28 Aug 2005, *A. Bhattacharjee 34807* (HOLOTYPE: CAL).

Zeuxini goodyeroidi Lindl. arte affinis, sed foliis non albocinereo-coloratis; bracteis dorse purpureoviridibus; inflorescentiis laxis, 2–3(-4) floriferis; floribus magnioribus; hypochilis lateraliter longiappendiculatis; epichilis mesochilis plus minusve ad 90°; pollinario longiore, multo longistipato et viscidio crassissimo differt.

Terrestrial, rhizomatous herb, 14.5–24 cm long. **Rhizome** subterranean, creeping, hardly distinguishable from the aerial stem, rooting at nodes, 3–5 cm long. **Roots** dull yellow-white, fleshy, tomentose, 3–6 cm long. **Aerial stem** erect, terete, glabrous, purple-green, 3–6 cm long. **Leaves** 4–6, petiolate; petiole sheathing at base, sheath membranous, clasping, pink-white, 7–10 mm long; lamina obliquely ovate-lanceolate, entire, acuminate, glossy, with dark velvety-green upper surface and purple-green lower surface, 12–36 × 7–15 mm, 7-veined. **Inflorescence** 2–3(–4) flowered in very lax spike. **Spike** terminal, peduncle terete, sparsely tomentose, 7–10 cm long, with 2 distant sheaths; sheaths ovate, cuspidate, clasping, membranous, glabrous, pink, 8–13 × 2–3 mm, 3-veined; rachis terete, sparsely tomentose, 1.8–3 cm long. **Flowers** resupinate, 1.2–1.6 cm long, pink-white, not fully open-

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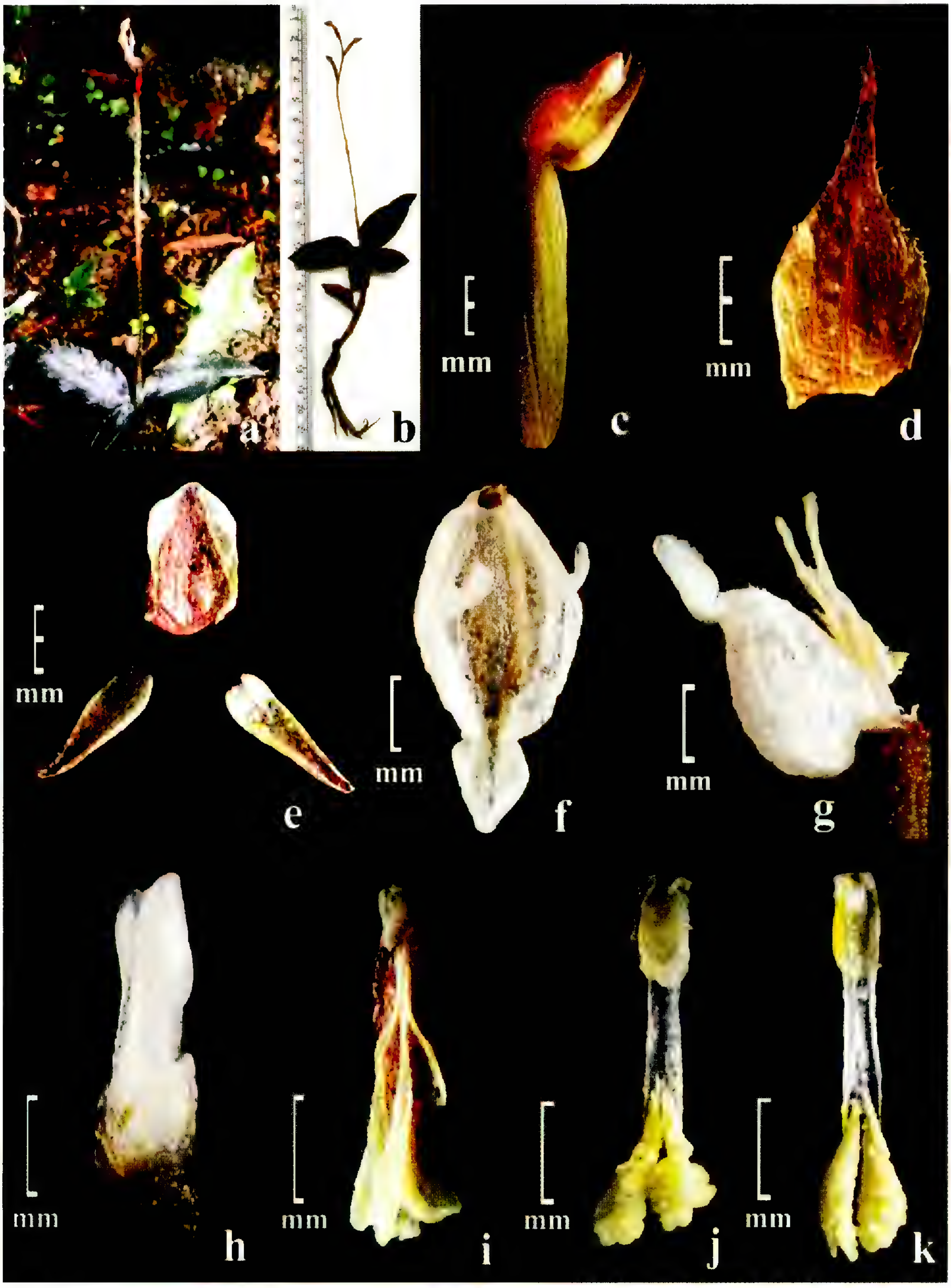


FIG. 1. *Zeuxine pantlingii* Av. Bhattacharjee & H.J. Chowdhery; **a.** habit, **b.** entire plant, **c.** flower, **d.** bract, **e.** sepals and petals, **f.** lip (top view), **g.** lip (lateral view) with bifid rostellum, **h.** column (in bud), **i.** anther cap, **j.** pollinia with stipe and viscidium (front), **k.** pollinia with stipe (tegula) and viscidium (back).

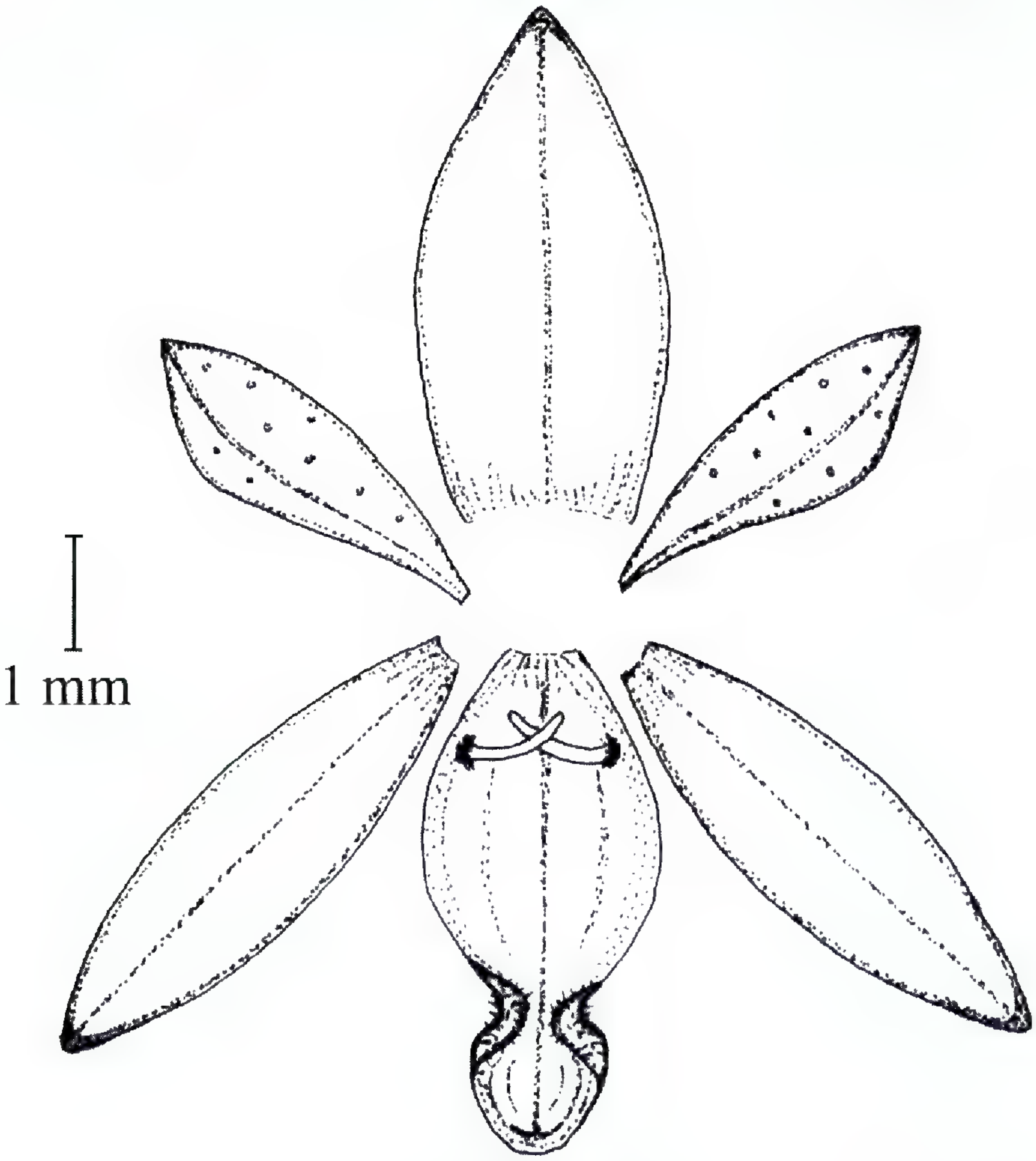


FIG. 2. Perigone (dissected) of *Zeuxine pantlingii* Av. Bhattacharjee & H.J. Chowdhery

ing. **Floral bracts** triangular-ovate, abruptly acuminate, more or less equaling the ovary, sparsely pubescent dorsally at basal region, finely serrated at margins, purplish-green, 9–11 × 4–4.5 mm (at widest end), 3-veined. **Sepals** unequal, free, glabrous; **dorsal sepal** ovate, acute, forming a hood with petals, pink-red, 4.5–5.5 × 2–3 mm, 1-veined; **lateral sepals** narrowly lanceolate, sub-acute, proximally dull green, distally pink-red, 5–6 × 1–2 mm, 1-veined. **Petals** obliquely falcate, acute, thin, with scattered minute dots, apically connate at a point, glabrous, white, 3–4 × 1–1.5 cm, 1- veined. **Lip** connate to the column base, white with light pink tinge, 4–5 mm long; **hypochile** broadly saccate, 2–3 mm broad when spread, each side internally with 1 erect, cornute, ca. 1 mm long lateral gland or appendage; **mesochile** very short, margins incurved to form a flap like structure on both sides, flap with minute hairs; **epichile** simple, obtuse, more or less perpendicular to mesochile, surface finely granular, 1–1.5 mm in diameter, margins slightly incurved. **Column** ca. 1 mm high, weakly winged below. **Anther** beaked, erect; anther cap narrowly triangular, dull white with red tinge, 3–3.5 mm long; **pollinia** 2, sectile, clavate, clefted, dull yellow-white, ca. 4 mm long; caudicles short; stipe (tegula) linear, semi-transparent, ca. 2.5 mm long; **viscidium** thick, oblong, dull straw-yellow. **Rostellum** bifid, 2–2.5 mm long; stigma with 2 lateral lobes, ovate; **ovary** pale-green, 11–12 × 2–2.5 mm.

Closely allied to *Zeuxine goodyeroides* Lindl. but differs in having leaves without any white-gray midvein; more broader, dorsally purplish-green bracts; larger flowers, 2–3 (–4) in lax inflorescence; hypochile with longer lateral appendages, epichile more or less

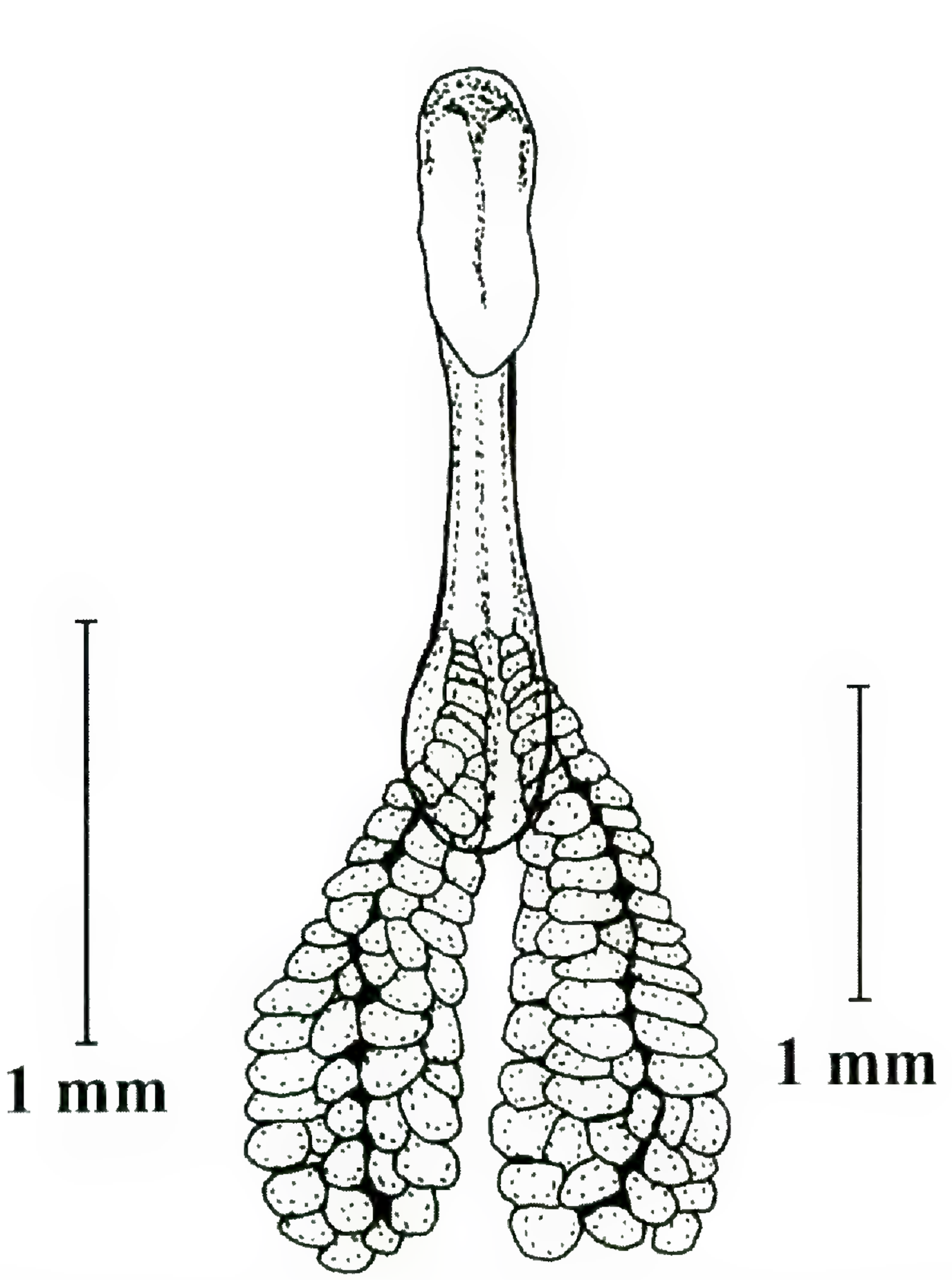


FIG. 3. Pollinarium of *Zeuxine goodyeroides* and *Zeuxine pantlingii* (compared).

perpendicular to the mesochile; longer pollinarium with much longer stipe and very thick, dull straw-yellow viscidium.

Flowering.—August–September

Distribution.—India, West Bengal, Darjeeling District, near Mongpoo, ca. 900 m.

Zeuxine pantlingii Av. Bhattacharjee & H.J. Chowdhery is closely allied to *Zeuxine goodyeroides* Lindl., but can be distinguished from several characters in Table 1.

Etymology.—The new species is named in honour of Robert Pantling (1856–1910), a British botanist known for his masterly drawings and colour paintings of Indian orchids.

Robert Pantling (1856–1910) (Fig. 4) was borne in North of England in the year 1856. His interest and passion for flowers helped him to get an apprenticeship in Duke's service at the age of 16. After three year's apprenticeship at the age of 19, Robert Pantling was admitted to the Royal Botanic Garden on 5 July, 1875. He left Kew on 14 July 1877 to join the Royal Botanic Gardens at Windsor. He came to India in 1879 as an assistant in Cinchona Department and subsequently appointed as Curator in the Royal Botanic Garden, Calcutta, but his deteriorating health and a new post of Senior Assistant took him back to Mongpoo in the Eastern Himalayan foothills in Darjeeling district where he spent his remaining service in India. At Mongpoo apart from carrying out official duties Pantling undertook many plant collection tours to Sikkim Himalayan region and collected hundreds of orchids. He prepared their drawings and published several new genera and a

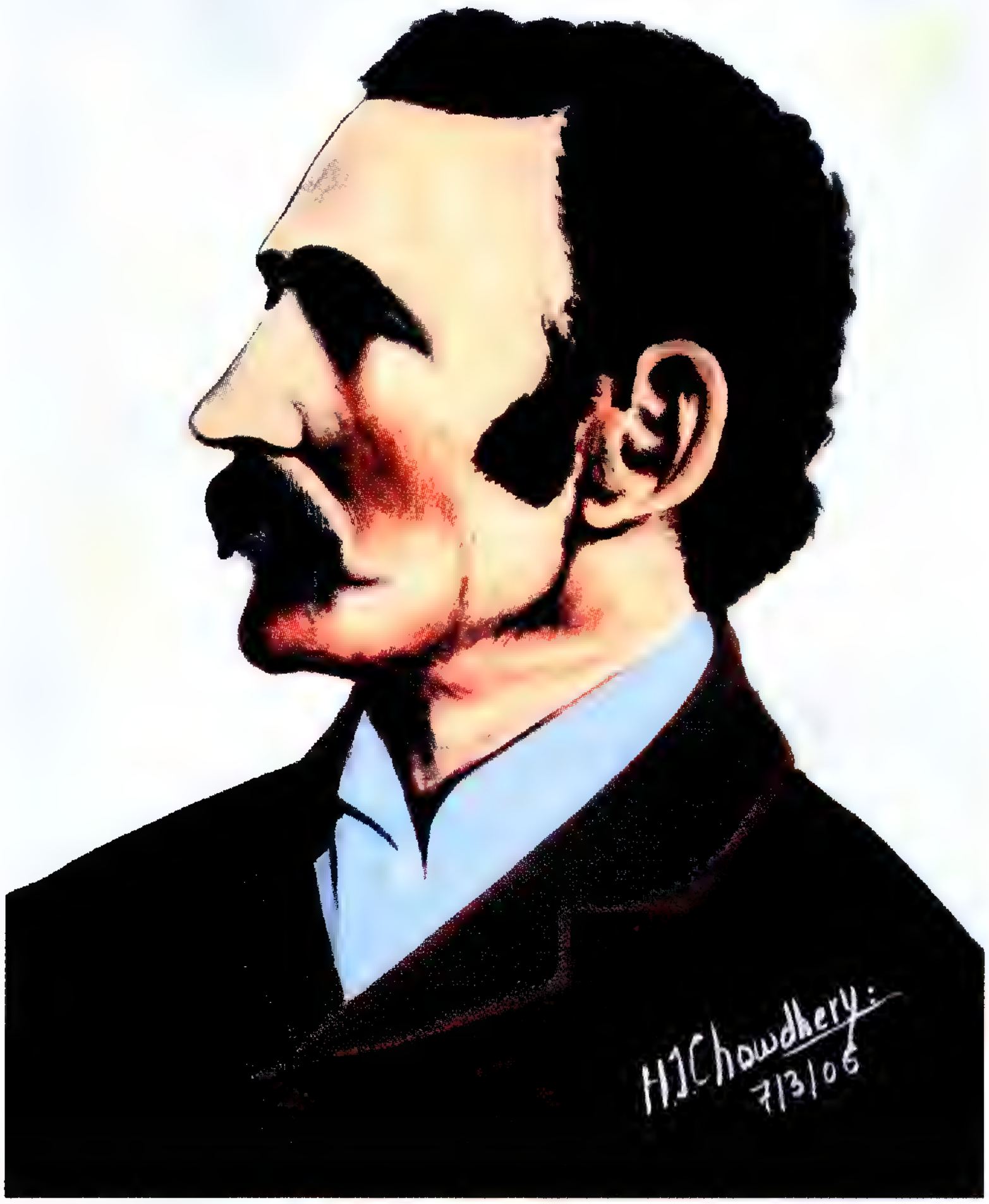


Fig. 4. Painting of Robert Pantling (1856–1910).

Table 1. Comparison between *Zeuxine goodyeroides* and *Zeuxine pantlingii*.

***Z. goodyeroides* Lindl.**	***Z. pantlingii* Av. Bhattacharjee & H.J. Chowdhery**
Leaves with a distinct, white-gray midvein.	**Leaves** without any white-gray midvein.
Inflorescence 3–16 flowered in comparatively dense spike.	**Inflorescence** 2–3(–4) flowered in very lax spike.
Bract narrower at base.	**Bract** broader at base.
Hypochile with shorter lateral glands or appendages within.	**Hypochile** with longer lateral glands or appendages within.
Epichile more or less horizontal to mesochile.	**Epichile** more or less perpendicular to mesochile.
Pollinarium shorter, with shorter stipe (tegula). Viscidium thin, transparent (in live specimen). Stipe slightly constricted near the middle (Fig. 3).	**Pollinarium** longer, with longer stipe (tegula). Viscidium very thick, dull straw-yellow (in live specimen). Stipe linear (Fig. 3).

very large number of new species in collaboration with George King, the then in-charge of Calcutta Botanic Garden. His hard official duties, field work and studying minute floral details of orchids and drawing large number of orchid illustrations impaired his eyesight and further deteriorated his health. Pantling's ailing health did not permit him to publish any work on orchids after his classic work on orchids, "Orchids of Sikkim Himalaya" in 1898, co-authored with George King. Pantling died at the age of 54 at Suez on his way back home. He served in India for 31 years. He was commemorated by the orchid genus *Pantlingia* and a large number of species.

Robert Pantling will be known for his meticulous, beautiful and unmatched, highly accurate scientific drawings and paintings of orchids of India, Myanmar and Malaysia drawn by him with great precision, which shows his skill and mastery over the subject. These drawings are preserved in the archival section of Central National Herbarium, Botanical Survey of India, Howrah.

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FOUR NOVELTIES AND A LECTOTYPIFICATION IN *MATELEA* (APOCYNACEAE: ASCLEPIADOIDEAE) FROM HISPANIOLA

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ABSTRACT

On-going study of subtribe Gonolobinae (Apocynaceae: Asclepiadoideae) in the West Indies resulted in the discovery of four new species from Hispaniola: **Matelea corynephora, M. phainops, M. rhynchocephala**, and **M. torulosa.** *Matelea pauciflora* is lectotypified.

RESUMEN

Se describen cuatro especies nuevas de *Matelea* de la Española como resultado del estudio de la subtribu Gonolobinae (Apocynaceae: Asclepiadoideae) en las Indias Occidentales: **Matelea corynephora, M. phainops, M. rhynchocephala** y **M. torulosa.** Se lectotipifica *Matelea pauciflora*.

Gonolobus pauciflorus Spreng. (Apocynaceae: Asclepiadoideae) was described in 1824 based on a Bertero specimen from Hispaniola (P!). Schlechter (1899) recognized the species, noting that at the time, it still remained known only from the Bertero collection. Erik Ekman subsequently contributed numerous new collections that were referred to *G. pauciflorus* by Ignatz Urban of B (fide annotations) and later accepted as well by Alain H. Liogier (fide annotations), author of the most recent treatment of Asclepiadoideae for Hispaniola (Liogier 1994). Woodson (1941) transferred *G. pauciflorus* to *Matelea* Aubl. as one of 105 new combinations that resulted in a very broadly circumscribed genus that is, in large part, still currently followed (see Stevens 2005). According to Woodson's (1941) generic concept, *Matelea* is distinguished from *Gonolobus* Michx. in part by the absence of laminar dorsal anther appendages (Cd sensu Kunze 1995) in the former. A seemingly related species—*Matelea linearipetala* Alain—was described in 1988 from a single 1926 Haitian specimen (*Ekman H7136*, S!) not seen by Urban. However, in the course of ongoing systematic study of subtribe Gonolobinae in the West Indies, it has become clear that *M. pauciflora* (Spreng.) Woodson sensu Urban and Liogier contains four additional undescribed species. The four new species are described and illustrated below. For clarity, amplified descriptions, as well as illustrations, are also provided for *M. linearipetala* and *M. pauciflora*. The six species are nearly indistinguishable in the absence of flowers—each bearing small, opposite, ovate-oblong leaves—but differ dramatically in various floral characteristics. A key follows. Corona terminology primarily follows Liede and Kunze (1993) and Kunze (1995), although it is recognized that additional work is needed to clarify family-wide homology (see Endress & Bruyns 2000; Livshultz 2003).

1. Calyx colleters 2 per sinus; long eglandular sharp trichomes (ca. 0.2 mm) of the pedicels retrorse; corolla lobes ocellate (i.e., each bearing a single white spot on the adaxial surface near the apex); gynostegial corona (C(is)) columnar at the base and appearing as a ca. 0.6 mm tall stipe; stylar head lacking a terminal appendage _____ **M. phainops**
1. Calyx colleters 0–1 per sinus; long eglandular sharp trichomes of the pedicels predominantly, if

not exclusively, antrorse or spreading; corolla lobes ocellate or not; gynostegial corona (C(is)) not basally columnar nor appearing as a stipe; stylar head with or without a terminal appendage.

2. Gynostegial corona (C(is)) with a broad, hardening, lobe-like, translucent yel ow golden se cretion in the interstaminal position (i.e., between the raised portions of the corona segments that rise to meet the lower portion of the anther in the staminal position); interstam'nal gynostegial corona (Ci) unlobed; anther wings horizontally divergent; stylar head exhibiting a terminal appendage or not.
   3. Gynostegial corona (C(is)) ca. 0.6–0.7 mm tall, staminal gynostegial corona (Cs) unlobed apically (i.e., descending smoothly in an arc from the apical ridge to the base); anther wings sl:ghtly longer than the corpusculum; terminal appendage of stylar head absent, sometime a short protuberance present, to 0.2 mm tall _____ **M. linearipetala**
   3. Gynostegial corona (C(is)) > 1 mm tall, staminal gynostegial corona (Cs) slightly vertically lobed apically (i.e., each r'dge slightly rising vertically immediately before descending to the base); anther wings slightly shorter than the corpusculum; terminal appendage of stylar head conic (volcano-shaped; broader at the base than at the apex), 0.9–1.2 mm tall _____ **M. pauciflora**

2. Gynostegial corona (C(is)) lacking a hardening, lobe-like, translucent yellow-golden secretion in the interstaminal position; interstaminal gynostegial corona (Ci) lobed (or if not, then the stylar head with a knob-shaped terminal appendage); anther wings horizontally conver gent at least at the apex or parallel; stylar head exhibiting a terminal appendage.
   4. Calyx colleters absent; corolla lobe bases each with two round, distinct, lateral thickenings, basal lobe surfaces concave ("scooped-out"); interstaminal gynostegial corona (Ci) unlobed, staminal gynostegial corona (Cs) apically ungrooved, unlobed laterally, scallop-shaped in broad outline, margins entire or somewhat undulating; anther wings parallel; terminal appendage of stylar head capitate (e.g., reminiscent of a round door knob), to 1.1 mm tall _____ **M. torulosa**
   4. Calyx colleters 1 per sinus; corolla lobe bases lacking round lateral thickenings, lobes plane; interstaminal gynostegial corona (Ci) shallowly to broadly lobed, staminal gynostegial corona (Cs) apically grooved or laterally lobed, not scallop-snaped; anther wings convergent at least apically; terminal appendage of stylar head clavate or narrowly elongate-conic (obelisk-shaped), > 1.8 mm tall.
      5. Interstaminal gynostegial corona (Ci) a large lobe, staminal gynostegial corona (Cs) grooved apically, lacking two broad, lateral lobes; terminal appendage of stylar head clavate _____ **M. corynephora**
      5. Interstaminal gynostegial corona (Ci) a shallow lobe, staminal gynostegial corona (Cs) apically not grooved, broadly lobed laterally to appear 3-lobed; terminal appendage of stylar head narrowly elongate-conic (obelisk shaped) _____ **M. rhynchocephala**

Matelea corynephora Krings, sp. nov. (**Fig. 1**). TYPE: HAITI: Ile la Tortue, la Vallée, top of Morne Barranca, ca. 300 m, 21 Mar 1928 (fl), *E.L. Ekman H9740* (HOLOTYPE: S!).

Species nova *Matelea* Aubl. differt a *Matelea* antillanarum corona magnilobata interstaminer, non lobata staminer, gynostegio corynephoro.

Slender, woody vine. Latex unknown. Stems ca. 1.8 mm diam., pubescent, glandular-capitate trichomes throughout, ca. 0.09 mm long, eglandular sharp trichomes mostly in 2 lines, one on each side of the stem, retrorse, ca. 0.4 mm long. Leaves opposite, simple, blades oblong to linear-oblong, (7.2–)12–25 × (3.6–)5.2–8.6 mm, apex obtuse, apiculate, base broadly cuneate to rounded, margins entire, adaxial surface dark green, glossy on drying, glabrous or minutely pubescent along midvein with short glandular-capitate trichomes, abaxial surface pubescent along midvein and sometime secondary veins, trichomes mostly glandular-capitate, eglandular sharp trichomes few and scattered, colleters 2; petioles 3.8–7 × ca. 0.6 mm, glandular-capitate trichomes dense, ca. 0.1 mm long, eglandular sharp trichomes dense, antrorse, ca. 0.2 mm long, both trichome types found throughout, but the longer sharp trichomes tending to be slightly denser along the adaxial

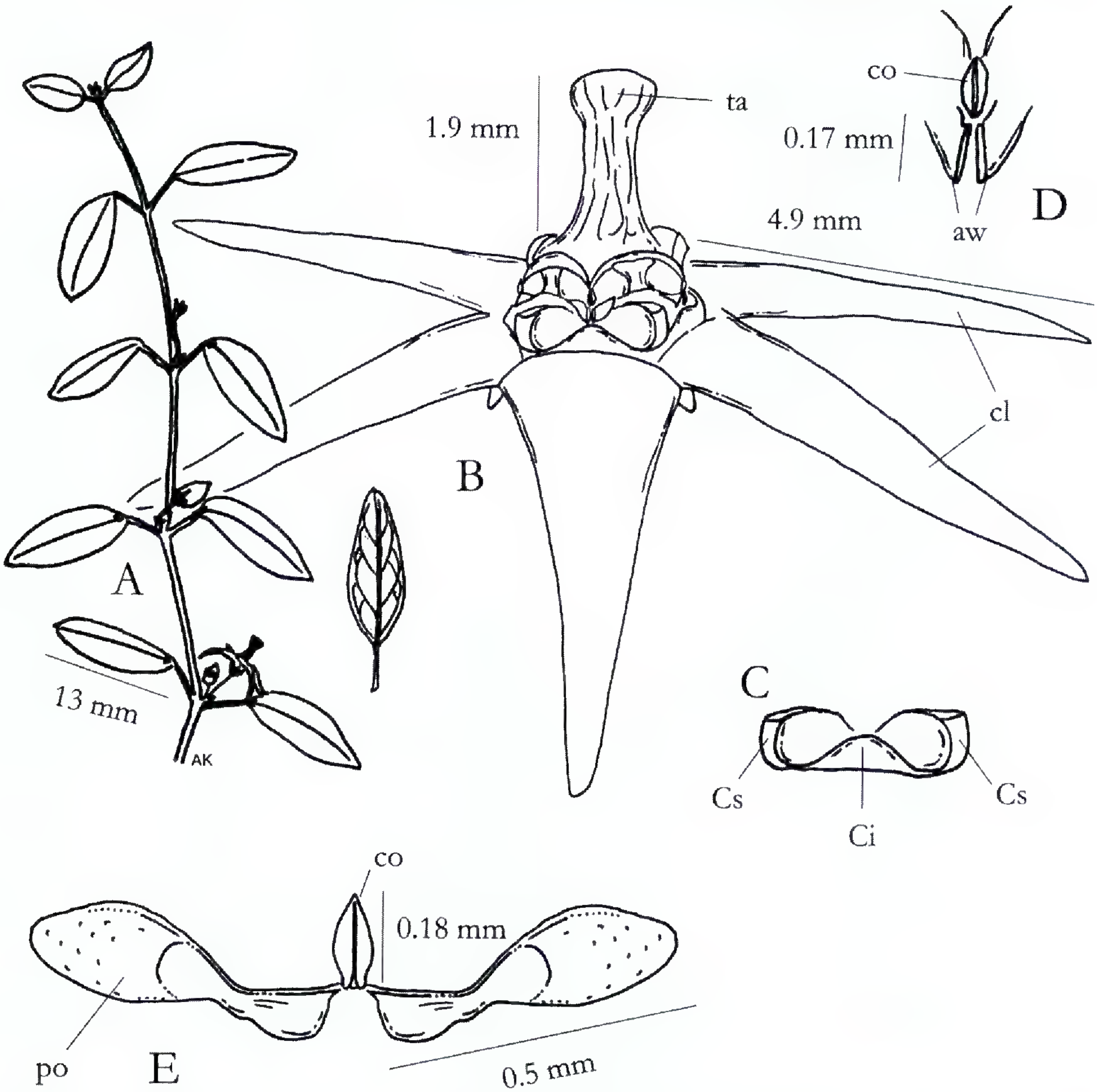


FIG. 1. *Matelea corynephora* Krings: **A,** habit and detail of leaf; **B,** flower with clavate terminal appendage of stylar head; **C,** gynostegial corona—note the laterally unlobed Cs, and the rounded lobe of the Ci; **D,** corpusculum and anther wings; **E,** pollinarium, caudicle shape approximate. Based on *Ekman H9740* (S). aw = anther wings; Ci = interstaminal gynostegial corona; cl = corolla lobes; co = corpusculum; Cs = staminal gynostegial corona; po = pollinium; ta = terminal appendage of stylar head.

petiolar ridge; stipular colleters 2, one on each side of petiole base, ca. 0.3 mm long. Inflorescence racemiform, peduncles 0.6–1.7 × ca. 1 mm, glandular capitate trichomes absent, eglandular sharp trichomes 0.2–0.3 mm long, antrorse; pedicels 3–5 × ca. 0.6 mm, glandular-capitate trichomes dense, ca. 0.04 mm long, longer eglandular sharp trichomes dense, ca. 0.2 mm long, antrorse. Calyx 5-lobed, lobes oblong-ovate, ca. 0.9 × 0.6 mm, apices obtuse, margins entire, adaxial surface glabrous, abaxial surface very sparsely pubescent with eglandular trichomes scattered near center and along the margins; colleters 1 per sinus. Corolla subrotate, bases campanulate, tube ca. 0.9–1.2 × 1.2–1.3 mm, 5-lobed, lobes imbricate in bud (not or only slightly dextrorse), green (fide collectoris), lanceolate-linear, 4.5–5.5 × 1.6–1.8 mm, apex obtuse, at least some ocellate (i.e., each lobe bearing a white eye adaxially at its apex), adaxial surface glabrous, abaxial surface glabrous or very

sparsely pubescent with trichomes eglandular. Faucal annulus (corolline corona or Ca) indistinct. Gynostegial corona of fused staminal (Cs) and interstaminal parts (Ci), ca. 0.7 mm tall, not appearing as a stipe, Cs rising to meet the bottom of the anther, rising segment lacking two broad, lateral lobes, but grooved apically, Ci broadly lobed; laminar dorsal anther appendages (Cd) absent. Pollinarium: corpuscula dark reddish-brown, ca. 0.15 mm long; pollinia borne horizontally or with the cavity slanting upwards at an angle, ovate, ca. 0.37 × 0.27 mm. Stylar head with a terminal appendage, appendage clavate, 1.9–2.2 mm long, 1.4–1.5 mm wide at the apex, generally broader at the apex than at the base, papillate throughout, a tuft of eglandular sharp trichomes present in the center of the apex, trichomes ca. 0.3 mm long. Follicles unknown.

Distribution.—Apparently endemic to Haiti [known only from the type].

Etymology.—The specific epithet refers to the conspicuous, clavate, terminal stylar head appendage.

Discussion.—*Matelea corynephora* appears closely related to *M. rhynchocephala* (Fig. 5) and *M. torulosa* (Fig. 6)—both latter species also exhibiting a stylar head with a terminal appendage. All three can be easily distinguished by the shape of the gynostegial corona, as well as that of the appendage (see key above and Figs. 1, 5–6). All three lack the broad, translucent yellow-golden, hardening secretions in the interstaminal position as seen in *M. linearipetala* (Fig. 2) and *M. pauciflora* (Fig. 3).

Matelea linearipetala Alain, Phytologia 64:346. 1988. (**Fig. 2**). TYPE: HAITI: on olig. limestone, ca. 200 m, Massif des Matheux, Thomazeau, Morne à Cabrits, a vine, fr. "luteis," 24 Oct 1926 (fl & fr), *E.L. Ekman H7136* (HOLOTYPE: S!) [n.v. Urban].

Slender, woody vine. Latex unknown. Stems ca. 0.9 mm diam., pubescent in two lines, less densely so with age, glandular-capitate trichomes, ca. 0.08 mm long, eglandular sharp trichomes to 0.45 mm long, retrorse. Leaves opposite, simple, blades oblong, oblong-ovate, or ovate, 17–45 × 9–21 mm, apices obtuse to rounded, apiculate, bases rounded to truncate, margins entire, adaxial surface dull glabrous, except minutely pubescent along the midvein, glandular-capitate trichomes ca. 0.08 mm long, eglandular sharp trichomes absent, abaxial surface glabrous, except minutely pubescent along the veins, glandular-capitate trichomes ca. 0.08 mm long, eglandular sharp trichomes very sparse if present, ca. 0.2 mm long, colleters 2; petioles 4.4–17 × ca. 0.4 mm, densely pubescent throughout, glandular-capitate trichomes ca. 0.07 mm long, eglandular sharp trichomes very sparse, ca. 0.3 mm long, antrorse to antrorse-appressed; stipular colleters 2, one on each side of petiole base, ca. 0.3 mm long. Inflorescence racemiform, peduncles 0.6–2 × ca. 0.7 mm, essentially glabrous; pedicels 2.5–5 × ca. 0.7 mm, densely pubescent throughout, glandular-capitate trichomes ca. 0.08 mm long, eglandular sharp trichomes absent or more or less uniform throughout, though sparsely so, ca. 0.18 mm long, predominantly antrorse or spreading. Calyx 5-lobed, lobes lanceolate to ovate-oblong, 1.7–2 × 0.8–1.2 mm, apices obtuse, pubescent, glandular-capitate trichomes ca. 0.08 mm long; colleters 1 per sinus. Corolla subrotate, bases subcampanulate, tube ca. 0.8 × 1 mm, 5-lobed, lobes imbricate in bud (not or only slightly dextrorse), green (fide collectoris), apparently not ocellate, linear lanceolate, 4.8–6.5 × 1.6–2 mm, apices obtuse, margins entire, adaxial surface glabrous, reticulate at least on drying, abaxial surface glabrous, except tube pubescent, glandular-capitate trichomes ca. 0.08 mm long. Faucal annulus (corolline corona or Ca) indistinct. Gynostegial corona of fused staminal (Cs) and interstaminal parts (Ci), Cs rising to meet the lower portion of the anther, rising segment a narrow ridge, triangular when

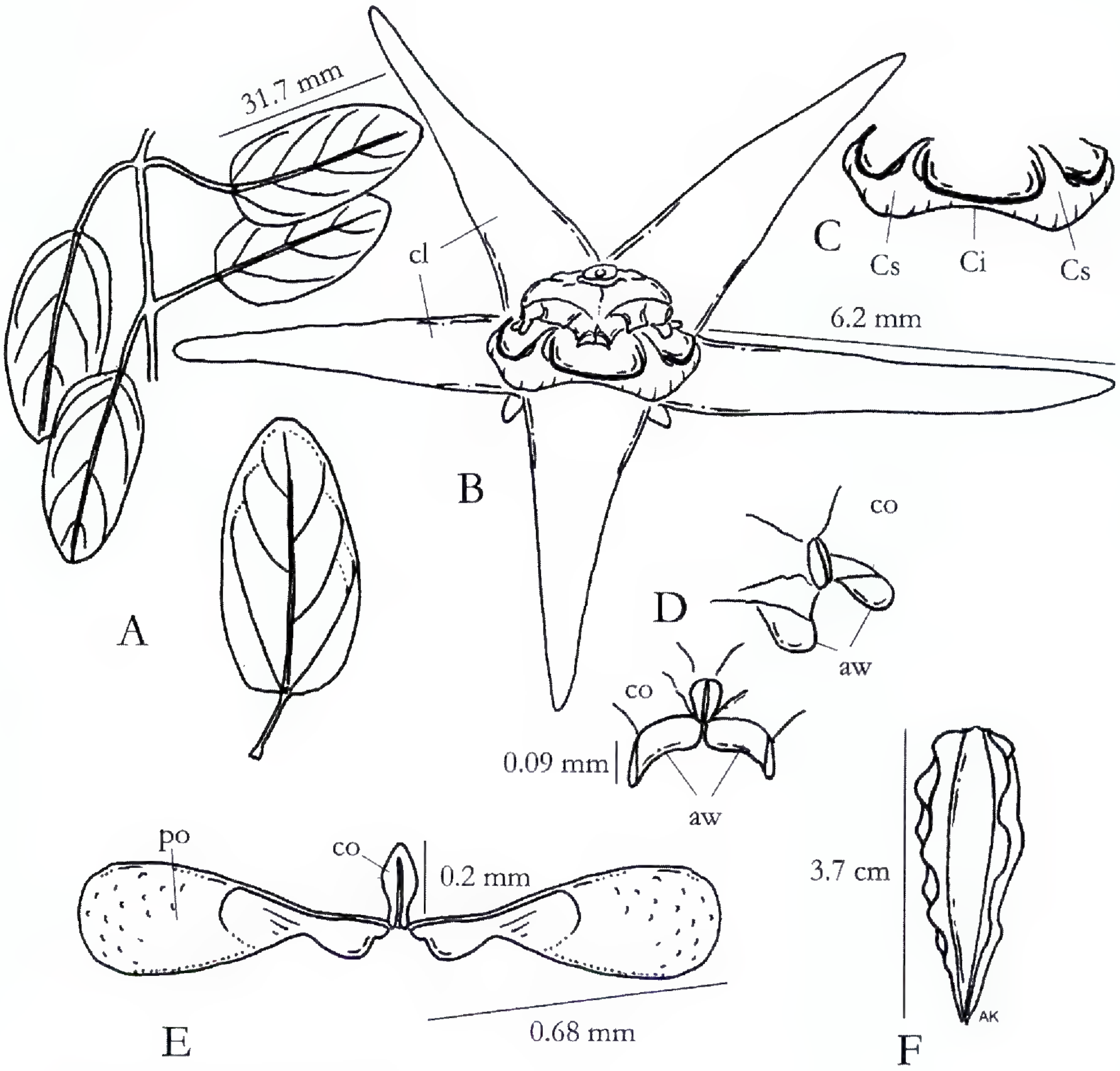


FIG. 2. *Matelea linearipetala* Alain: **A,** habit and leaf detail; B, flower; **C,** gynostegial corona; **D,** corpuscula and anther wings; **E,** pollinarium, caudicle shape approximate; **F,** follicle. Based on *Ekman H7136 & H9067* (S). aw = anther wings; Ci = interstaminal gynostegial corona; cl = corolla lobes; co = corpusculum; Cs = staminal gynostegial corona; po = pollinium.

viewed directly from the front, neither laterally nor vertically lobed, ca. 0.67 mm tall, Ci unlobed, exhibiting a broad, hardening, lobe-like, translucent yellow-golden, secretion; anther wings with divergent apices, only nearly touching at the base immediately subtending the corpusculum, vertical length immediately subtending corpusculum ca. 0.09 mm long, horizontal length ca. 0.15 mm long; laminar dorsal anther appendages (Cd) absent. Pollinaria: corpuscula dark reddish-brown, ca. 0.15 mm long; pollinia borne horizontally, ovate, ca. 0.34 × 0.2 mm. Stylar head lacking a pronounced terminal appendage, sometimes exhibiting a slightly raised, circular or angular protuberance, ca. 0.2 mm tall. Follicle (immature?) 3.7 × 1.4 cm, 5-winged, wings interrupted and appearing as dentate lobes, surface appearing glabrous, but minutely papillate throughout. Seeds unknown.

Distribution.—Apparently endemic to Haiti.

Additional specimens seen: **HAITI:** Massif des Cabos, Les Gonaïves, Petite-Gouyne, dry limestone region, hillsides, in thickets, vine, fl. green, ca. 150 m, 26 Sep 1927 (fl), *E.L. Ekman H9067* (C!, GH!, S!) [Referred to *G. pauciflorus*

by Urban and *M. pauciflora* by Liogier fide annotations. A handwritten note in pencil by Ekman on the S sheet indicates Ekman's suspicion of its novelty, although without recognizing salient characters: "Seems to come close to *G. pauciflorus*, but the umbellae are mostly one-flowered and the peduncle very short."]; Ile la Gonave, Pte-à-Raquettes, hillsides, fl. green, 3 Aug 1927 (fl), *E.L. Ekman H8809* (US!, S!) [Referred to *G. pauciflorus* by Urban and *M. pauciflora* by Liogier fide annotations. Ekman's handwritten note in pencil on the S sheet adds to the locality information: "I have not analyzed the flowers but the veg. characters seem to agree fairly well with this [*G. pauciflorus*]. Better plant. Coll. before!" However, "*pauciflorus*" was crossed out in pencil and a question mark placed above the epithet, suggesting perhaps a later second-guess by Ekman.].

Matelea pauciflora (Spreng.) Woodson, Ann. Missouri Bot. Gard. 28:226. 1941. (**Fig. 3**).

BASIONYM: *Gonolobus pauciflorus* Spreng., Systema Vegetabilium, editio decima sexta 1:846. 1824. TYPE: HISPANIOLA: 'St. Dominique,' *Bertero s.n.* (LECTOTYPE, here designated: P!).

Slender, woody vine. Latex unknown. Stems ca. 1.7 mm diam., pubescent throughout or in two lines, glandular-capitate trichomes ca. 0.07 mm long, eglandular sharp trichomes ca. 0.3 mm long, retrorse. Leaves opposite, simple, blades oblong or ovate, 8.5–56.5 × 5.3–27.8 mm, apices obtuse, bases rounded to truncate, margins entire, adaxial surface dull, glabrous except minutely pubescent along midvein, glandular-capitate trichomes ca. 0.05 mm long, eglandular sharp trichomes sparsely scattered, ca. 0.18 mm long, abaxial surface glabrous except pubescent along the veins, glandular-capitate trichomes ca. 0.08 mm long, eglandular sharp trichomes sparsely scattered, ca. 0.4 mm long, colleters 2; petioles 3.6–22.2 × ca. 0.4 mm, densely pubescent throughout, glandular-capitate trichomes ca. 0.1 mm long, eglandular sharp trichomes scattered throughout, ca. 0.23 mm long, predominantly antrorse or spreading; stipular colleters 2, one on each side of petiole base, ca. 0.2 mm long. Inflorescence racemiform, peduncles to 5 × ca. 0.4 mm, glabrous or pubescent, glandular-capitate trichomes ca. 0.08 mm long, eglandular sharp trichomes sparse, ca. 0.36 mm long, antrorse or spreading; pedicels to 9 × ca. 0.4 mm, densely pubescent, glandular-capitate trichomes ca. 0.05 mm long, eglandular sharp trichomes ca. 0.3 mm long, predominantly antrorse or spreading. Calyx 5-lobed, lobes lanceolate to lance-ovate, 1.3–2.5 × 0.4–1 mm, apices obtuse, bases pubescent, glandular-capitate trichomes ca. 0.05 mm long, margins with eglandular sharp trichomes ca. 0.1 mm long, otherwise glabrous; colleters 1 per sinus. Corolla subrotate, bases subcampanulate, tube ca. 0.9 × 1.2 mm, 5-lobed, lobes imbricate in bud (not dextrorse), green (fide collectoris), apparently not ocellate, linear-lanceolate, 4.7–7.5 × 2–2.8 mm, apices obtuse, margins entire, adaxial surface glabrous, abaxial surface glabrous, except tube pubescent, glandular-capitate trichomes ca. 0.05 mm long. Faucal annulus (corolline corona or Ca) indistinct. Gynostegial corona of fused staminal (Cs) and interstaminal (Ci) parts, Cs rising to meet the lower portion of the anther, rising segment swollen at the base, slightly vertically lobed along the apical ridge, ca. 1.25 mm tall, Ci unlobed, exhibiting a broad, hardening, lobe-like, translucent yellow-golden, secretion; anther wings with divergent apices, only nearly touching at the base immediately subtending the corpusculum, vertical length immediately subtending corpusculum ca. 0.08 mm long, horizontal length ca. 0.18 mm; laminar dorsal anther appendages (Cd) lacking. Pollinarium: corpuscula dark reddish-brown, 0.18–0.2 mm long; pollinia borne horizontally or at a slightly upwards angle, oblong, ca. 0.42 × 0.24 mm. Stylar head with a terminal appendage, appendage volcano-shaped, ca. 0.9–1.2 mm tall. Follicle unknown.

Distribution.—Haiti and Dominican Republic.

Discussion.—Although bearing a conic terminal appendage of the stylar head, *M. pauciflora* (Fig. 3) appears more closely related to *M. linearipetala* (Fig. 2) than the other three terminally-appendaged species—*M. corynephora* (Fig. 1), *M. rhynchocephala* (Fig.

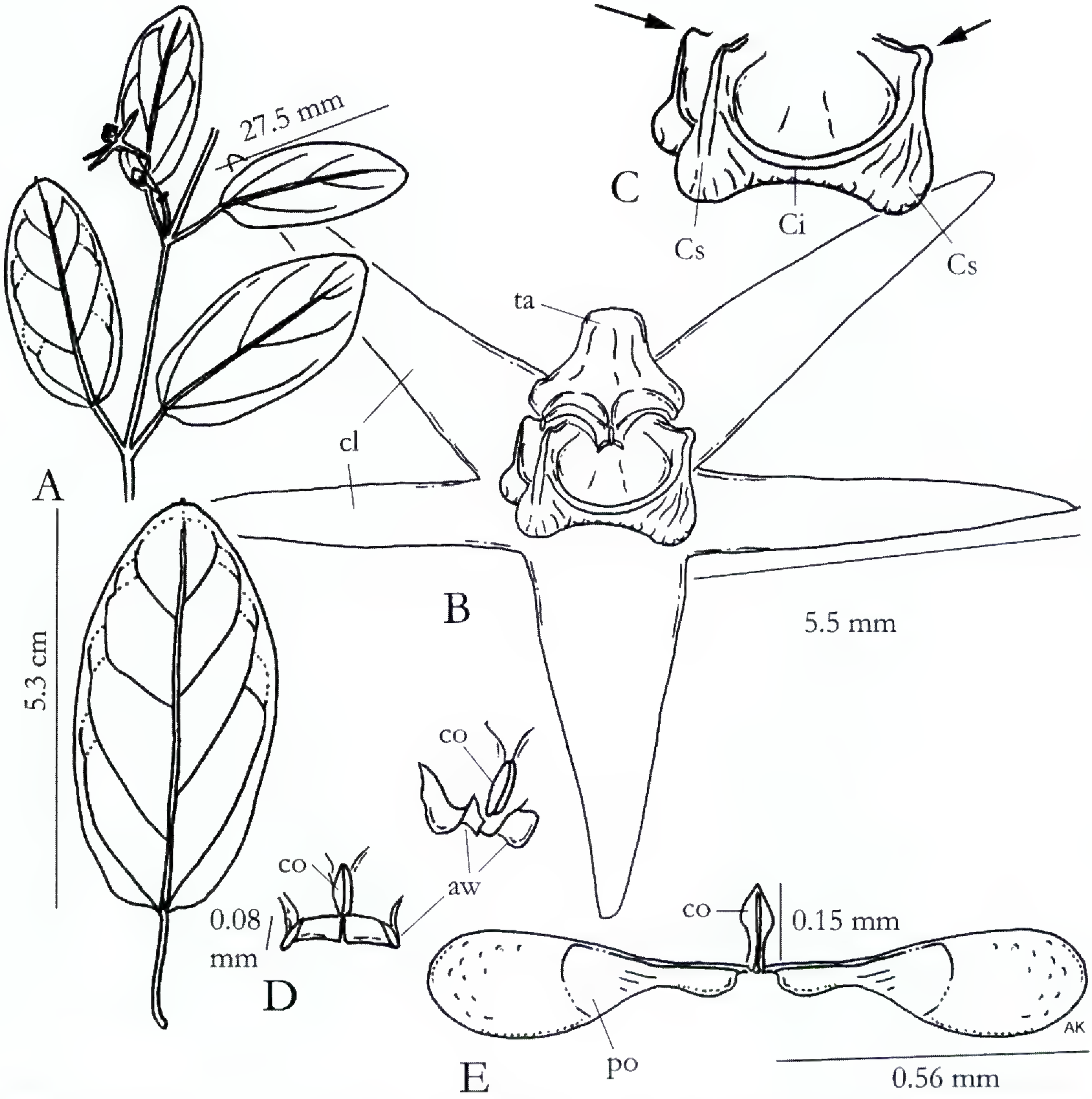


FIG. 3. *Matelea pauciflora* (Spreng.) Woodson: **A,** habit and leaf detail; **B,** flower with conic terminal appendage of stylar head; **C,** gynostegial corona—note slight vertical lobe of each Cs ridge (arrowed); **D,** corpuscula and anther wings; **E,** pollinarium, caudicle shape approximate. Based on *Ekman H6171* (K). aw = anther wings; Ci = interstaminal gynostegial corona; cl = corolla lobes; co = corpusculum; Cs = staminal gynostegial corona; po = pollinium; ta = terminal appendage of stylar head.

5), and *M. torulosa* (Fig. 6)—based on the shape of the gynostegial corona, the presence of broad, hardening, lobe-like, translucent yellow-golden, secretion in the interstaminal position, and the shape of the anther wings. *Matelea linearipetala* lacks a terminal appendage of the stylar head and can be additionally distinguished from *M.pauciflora* by the height and shape of the gynostegial corona (Fig. 2).

Additional specimens seen: **HAITI. Départ. d'Artibonite:** in a little valley not far from Mirabalais, shrubby Laubwald, 26 Oct 1924 (fl), *E.L. Ekman H2266* (GH!, IJ!, NY!, US!) [The sheet at US additionally includes the text: "on roadside, rare, 150 m." Annotations referring the specimens here appear by Urban, Woodson, and Liogier. Ekman slips in pencil are lacking.]; Massif du Nord, Hinche, Morne Juan-Gomez, oligocene limestone, in thickets, ca. 700 m, 23 May 1926 (fl), *E.L. Ekman H6171* (K!, S!) [In referring the collection only to *Poicillopsis*, Ekman's handwritten note in pencil on the S sheet indicates his unfamiliarity with the taxon. This specimen is the second

earliest of his collections in the *M. pauciflora* "complex." He is correct in noting "same as n. 2266."]. **DOMINICAN REPUBLIC. Prov. Azua:** Cordillera Central, 5 km al S del Pueblo de Padre Las Casas, en una lomita situada en el lado E de la carretera hacia Las Yayas, bosque seco con Ziziphus, Agave y Bursera, 18° 41'N, 70° 55'W, elev. 680–700 m, 2 Oct 1987 (fl), *R. Garcia y J. Pimentel 2531* (MO!) [Referred only to *Matelea* prior to this study]; Bani, vine flowers greenish, in thickets, 24 Sep 1966 (fl), *Bro. B.A. Lavastre 2290* (NY!) [Referred here by Liogier fide annotation].

Matelea phainops Krings, sp. nov. (**Fig. 4**). TYPE: DOMINICAN REPUBLIC: vine, up to 1.5 m high, flowers yellowish green, in thickets, about 2 mi W of Oviedo, alt. about sea level, on limestone, 3 Nov 1989 (fl), *A.H. Liogier 16617* (HOLOTYPE: GH!; ISOTYPES: NY!, USF!).

Species nova *Matelea* Aubl. differt a *Matelea* antillanarum forma coronae et gynostegi (v. Fig. 4).

Slender, woody vine. Latex unknown. Stems ca. 2.12 mm diam., pubescent, glandular-capitate trichomes throughout, ca. 0.12 mm long, eglandular sharp trichomes mostly in 2 lines, one on each side of the stem, retrorse, ca. 0.36 mm long. Leaves opposite, simple, blades oblong or ovate, (8–)12–31 × (–4)6–14 mm, apices obtuse, apiculate, bases broadly cuneate to rounded or subtruncate, margins entire, adaxial surface dull to somewhat glossy on drying, glandular-capitate trichomes throughout, but most dense along the veins, ca. 0.13 mm long, eglandular sharp trichomes scattered on midvein or absent, to 0.4 mm long, abaxial surface glabrous, except for short glandular-capitate trichomes along the vines, ca. 0.05 mm long, colleters 2–3; petioles to 10 × ca. 0.6 mm, glandular-capitate trichomes dense, ca. 0.1 mm long, eglandular sharp trichomes occassional or scattered, antrorse, ca. 0.22 mm long; stipular colleters 2, one on each side of petiole base, ca. 0.23 mm long. Inflorescence racemiform, peduncles to ca. 2.5 × 0.6 mm, glandular-capitate trichomes dense throughout, ca. 0.08 mm long, eglandular sharp trichomes scattered, spreading or antrorse, 0.17–0.2 mm long; pedicels 4–7 × ca. 0.36 mm, short trichomes both capitate and sharp, dense, ca. 0.09 mm long, longer eglandular sharp trichomes, if present, scattered and retrorse, ca. 0.2 mm long. Calyx 5-lobed, lobes ovate, 0.85–1.3 × 0.6–0.9 mm, apices obtuse, margins entire, glabrous, adaxial surface glabrous, abaxial surface minutely glandular pubescent; colleters 2 per sinus. Corolla subrotate, bases subcampanulate, tube ca. 0.4 × 0.5 mm, 5-lobed, lobes imbricate in bud (not or only slightly dextrorse), oblong-linear, 2.5–2.7 × 1.2–1.4 mm (width at base), apex obtuse, yellowish green (fide Liogier), each lobe bearing a white eye at its apex, adaxial surface glabrous, abaxial surface glabrous, except tube pubescent, glandular trichomes ca. 0.09 mm. Faucal annulus (corolline corona or Ca) indistinct. Gynostegial corona of fused staminal (Cs) and interstaminal parts (Ci), basally fused and appearing as a stipe, ca. 0.6 mm tall, upper Cs undulating, rising to meet the bottom of the anther in the staminal position, Ci unlobed; laminar dorsal anther appendages (Cd) absent. Pollinarium: corpuscula dark reddish-brown, ca. 0.13 mm long; pollinia borne horizontally, ovate, ca. 0.4 × 0.2 mm. Stylar head lacking a terminal appendage. Follicles unknown.

Distribution.—Apparently endemic to the Dominican Republic [known only from the type].

Etymology.—This vine is named in honor of my wife, the 'Bright eyes' in my life. The epithet also reflects the ocellate corolla lobes exhibited by this species.

Discussion.—*Matelea phainops* appears related to the Cuban *Matelea oblongata*, *M. acuminata*, and *M. nipensis* (Urb.) Woodson and, perhaps, Jamaican *Jacaima costata* (Urb.) Rendle. It is one of several mostly West Indian taxa exhibiting ocellate corolla lobes. Continental representatives likely include *M. pusilliflora* W.O. Williams, *M. ocellatus* W.D. Stevens, and the recently described *M. emmartinezii* W.D. Stevens. In addition to the afore-

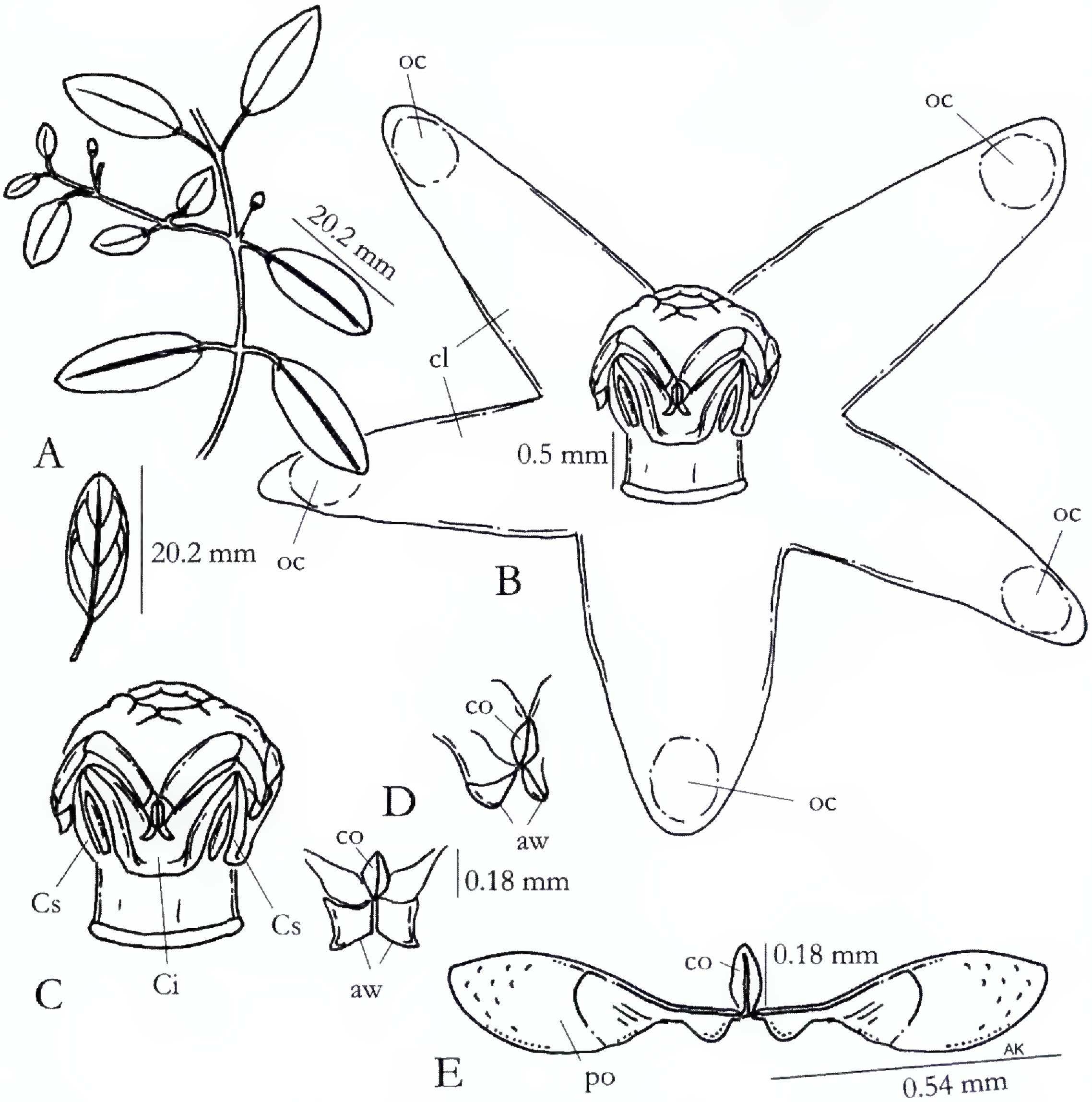


FIG. 4. *Matelea phainops* Krings: **A,** habit and leaf detail; **B,** flower—note ocellate corolla lobes; **C,** gynostegium with stipe-like base; **D,** corpuscula and anther wings; **E,** pollinarium, caudicle shape approximate. Based on *Liogier 16617* (GH). aw = anther wings; Ci = interstaminal gynostegial corona; cl = corolla lobes; co = corpusculum; Cs = staminal gynostegial corona; oc = ocellae; po = pollinium.

mentioned, small flowered species, larger flowered taxa likely belonging to the complex in the West Indies include *M. bayatensis* (Urb.) Woodson, *M. correllii* Spellman, and *M. tigrina* (Griseb.) Woodson. The latter may not be specifically distinct (see Krings 2005). The morphology of the gynostegial corona is variable in the group—from indistinct to well-developed—and additional research is necessary to clarify specific relationships.

Matelea rhynchocephala Krings, sp. nov. (**Fig. 5**). TYPE: DOMINICAN REPUBLIC. PROV. SANTIAGO: Valle del Cibao, Santiago, Hato del Yaque, in thickets, fl. green, fruiting, 15 Feb 1930 (fl & fr), *E.L. Ekman H14296* (HOLOTYPE: S!) [n.v. Urban; referred to *M. pauciflora* by Liogier fide annotation].

Species nova *Matelea* Aubl. differt a *Matelea* antillanarum corona parvilobata interstaminer, lobata staminer, gynostegio rhynchophoro.

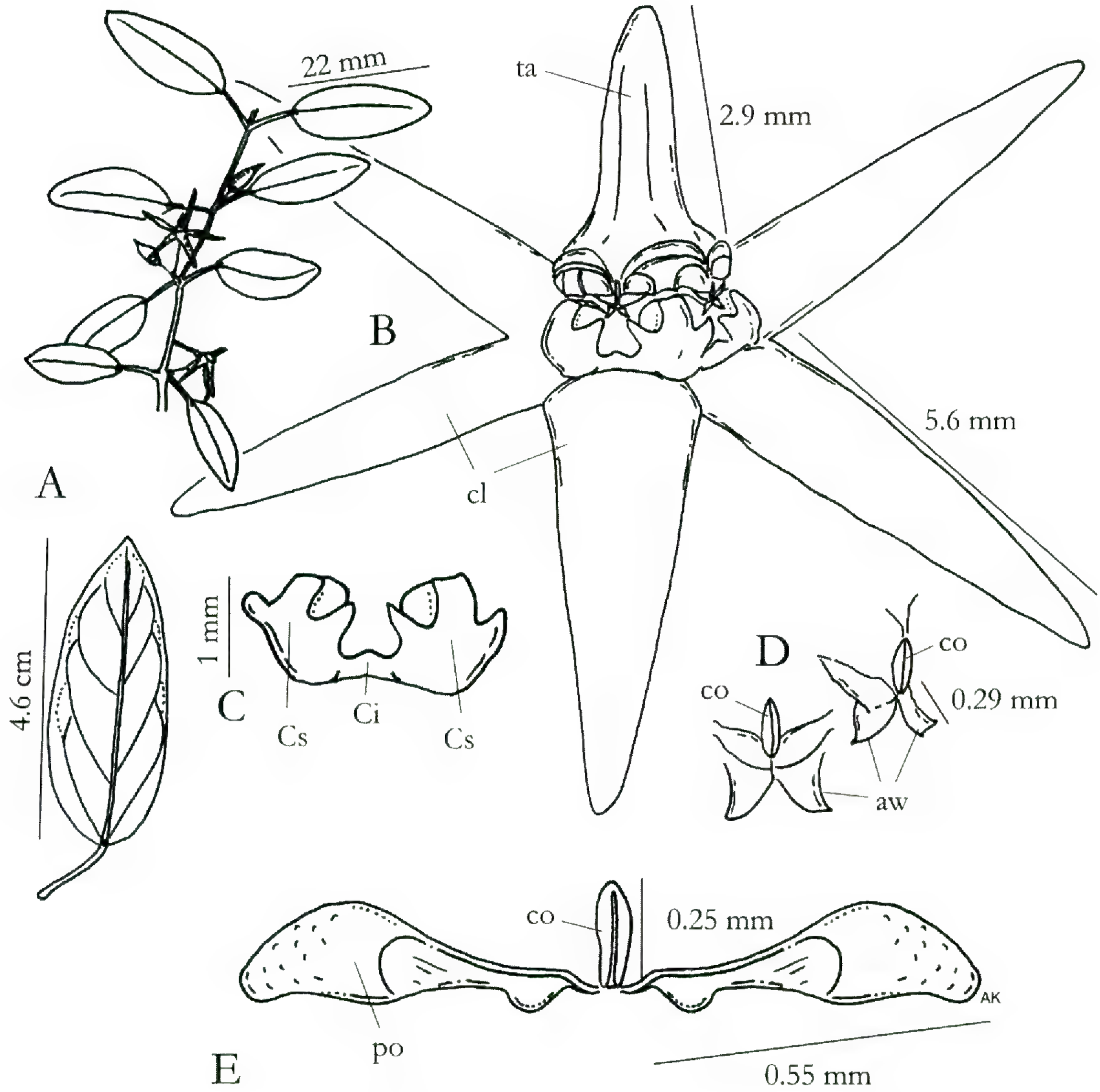


FIG. 5. *Matelea rhynchocephala* Krings: **A,** habit and leaf detail; **B,** flower; **C,** gynostegial corona—note trilobed Cs and shallow lobe of Ci; **D,** corpuscula and anther wings; **E,** pollinarium, caudicle shape approximate. Based on *Ekman H14296* (S). aw = anther wings; Ci = interstaminal gynostegial corona; cl = corolla lobes; co = corpusculum; Cs = staminal gynostegial corona; po = pollinium; ta = terminal appendage of stylar head.

Slender, woody vine. Latex unknown. Stems ca. 1.2 mm diam., densely pubescent throughout, though 2 lines somewhat evident on older stems, glandular-capitate trichomes ca. 0.06 mm long, eglandular sharp trichomes ca. 0.4 mm long, retrorse or spreading. Leaves opposite, simple, blades oblong or ovate, 19–48 × 7–20 mm, apices obtuse, apiculate, bases rounded to truncate, margins entire, adaxial surface dull on drying, not glossy, glabrous or pubescent along the midvein, glandular-capitate trichomes ca. 0.1 mm long, eglandular sharp trichomes absent or essentially so, abaxial surface glabrous, pubescent along the veins, glandular-capitate trichomes ca. 0.1 mm long, eglandular sharp trichomes to 0.2 mm long, colleters 2; petioles to 14 × ca. 0.45 mm, densely pubescent, glandular-capitate trichomes ca. 0.07 mm long, eglandular sharp trichomes ca. 0.3 mm long, throughout, antrorse; stipular colleters 2, one on each side of petiole base, ca. 0.2 mm long. Inflores-

cence racemiform, peduncles ca. 0.8 × 0.5 mm, pubescence as that of stems; pedicels 1.7–1.8 × ca. 0.44 mm, densely pubescent, glandular-capitate trichomes ca. 0.09 mm long, eglandular sharp trichomes ca. 0.2 mm long, antrorse or spreading. Calyx 5-lobed, lobes lanceolate, 1.5–1.6 × 0.5–0.6 mm, glandular-capitate trichomes mostly at the base, ca. 0.07 mm long, glandular sharp trichomes mostly near the middle, ca. 0.2 mm long; colleters 1 per sinus. Corolla subrotate, bases subcampanulate, tube ca. 1 × 1 mm, 5-lobed, lobes imbricate in bud (not or only slightly dextrorse), green (fide collectoris), linear-lanceolate, 4.9–5.9 × 1.1–1.4 mm, apex obtuse, margins white, adaxial surface glabrous, abaxial surface glabrous in age, except tube densely pubescent, glandular-capitate trichomes ca. 0.07 mm long. Faucal annulus (corolline corona or Ca) indistinct. Gynostegial corona of fused staminal (Cs) and interstaminal (Ci) parts, Cs rising to meet the lower portion of the anther, rising segment with a single, broad lobe on either side, ca. 0.8–0.9 mm tall, Ci shallowly lobed; anther wings triangular in frontal view, nearly touching; laminar dorsal anther appendages (Cd) absent. Pollinarium: corpuscula dark reddish-brown, ca. 0.3 mm long, pollinia borne horizontally or with the cavity slanting upwards at an angle, ovate, ca. 0.4 × 0.25 mm. Stylar head with a terminal appendage, appendage narrowly elongate-conical (obelisk-shaped), 2.8–3.3 × 0.6–0.8 mm, papillate, apex obtuse, with a tuft of eglandular trichomes or glabrous. Follicles ovate, 5.3–1.9 cm, 5-winged, wings interrupted and appearing as dentate lobes, glabrous. Seeds ovate, ca. 4.9 × 3.4 mm, glabrous, margins smooth, neither warty, nor dentate.

Distribution.—Apparently endemic to the Dominican Republic.

Etymology.—The specific epithet refers to the obelisk-shaped or snout-like terminal appendage of the stylar head.

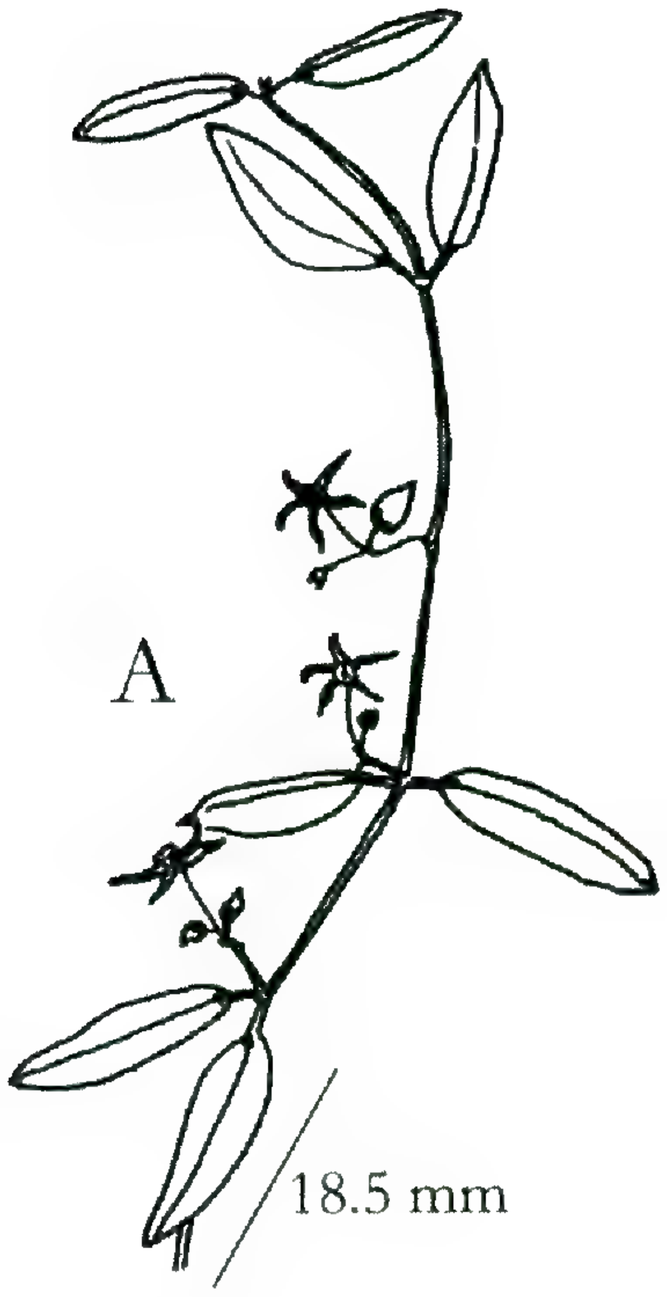
Discussion.—Matelea rhynchocephala (Fig. 5) appears most closely related to *M. corynephora* (Fig. 1) of Haiti. Notable differences between the two are the shape of the terminal appendage of the stylar head (obelisk-shaped in *M. rhynchocephala* vs. clavate in *M. corynephora)* and the shape of the gynostegial corona (Figs. 1 & 5).

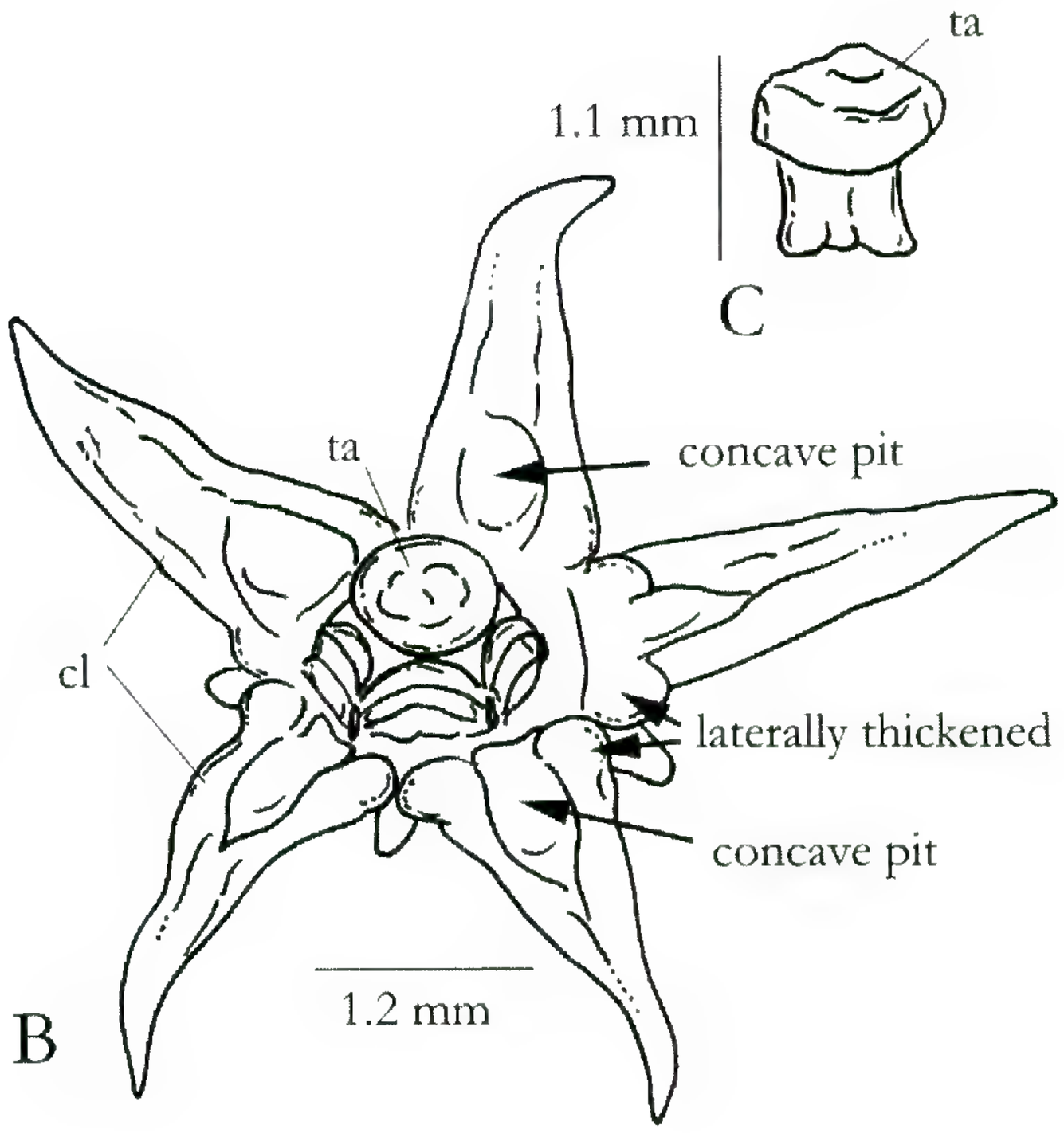
Additional specimen seen: **DOMINICAN REPUBLIC:** El Rubio, 22 Nov 1940 (fl), *M. Canela s.n.* (NY!) [Referred to *M. pauciflora* by Liogier fide annotation].

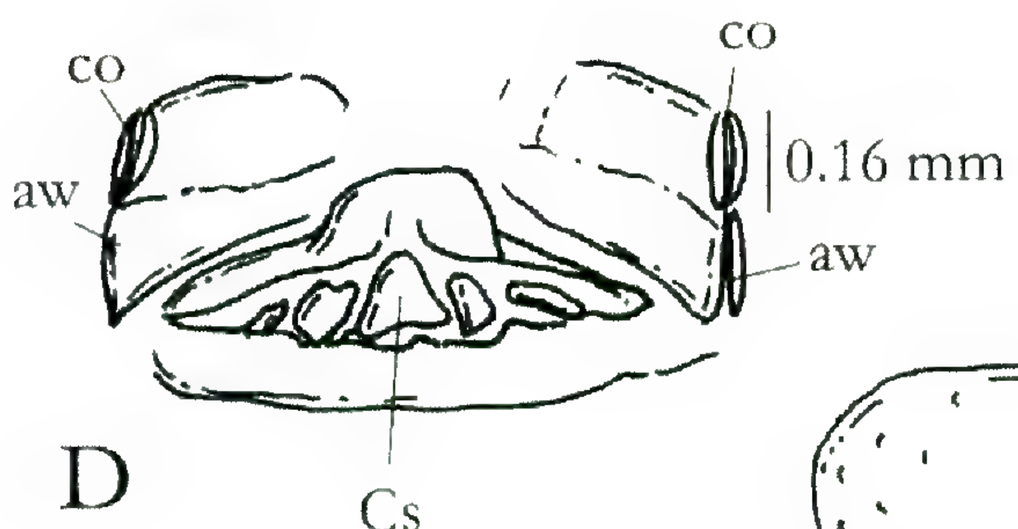
Matelea torulosa Krings, sp. nov. (**Fig. 6**). TYPE: DOMINICAN REPUBLIC. DISTR. NACIONAL: Los 3 Ojos de Agua, near Santo Domingo, 31 Oct 1959 (fl), *E. Marcano [J.J. Jiménez] 4096* (HOLOTYPE: US!) [referred to *M. pauciflora* by Liogier fide annotation].

Species nova *Matelea* Aubl. differt a *Matelea* antillanarum corona non lobata interstaminer, non lobata staminer, gynostegio toruloso.

Slender, woody vine. Latex unknown. Stems ca. 1.2 mm diam., densely pubescent in two lines, glandular-capitate trichomes ca. 0.05 mm long, eglandular sharp trichomes ca. 0.4 mm long, retrorse. Leaves opposite, simple, blades oblong or ovate, 9–28 × 3–8.8 mm, apices obtuse, apiculate, bases rounded or broadly cuneate, margins entire, adaxial surface dull, glabrous except pubescent along the midvein, glandular-capitate trichomes ca. 0.07 mm long, eglandular sharp trichomes sparse, to 0.18 mm long, abaxial surface pubescent primarily along the veins, glandular-capitate trichomes ca. 0.1 mm long, eglandular sharp trichomes to 0.4 mm long, colleters 2–3; petioles 2–6 × ca. 0.4 mm, densely pubescent throughout, glandular-capitate trichomes ca. 0.05 mm long, eglandular sharp trichomes ca. 0.33 mm long, antrorse to antrorse-appressed, not spreading or rarely so; stipular colleters 2, one on each side of petiole base, ca. 0.22 mm long. Inflorescence racemiform, peduncles to 4.9 × ca. 0.7 mm, densely pubescent throughout, glandular-capitate tri-







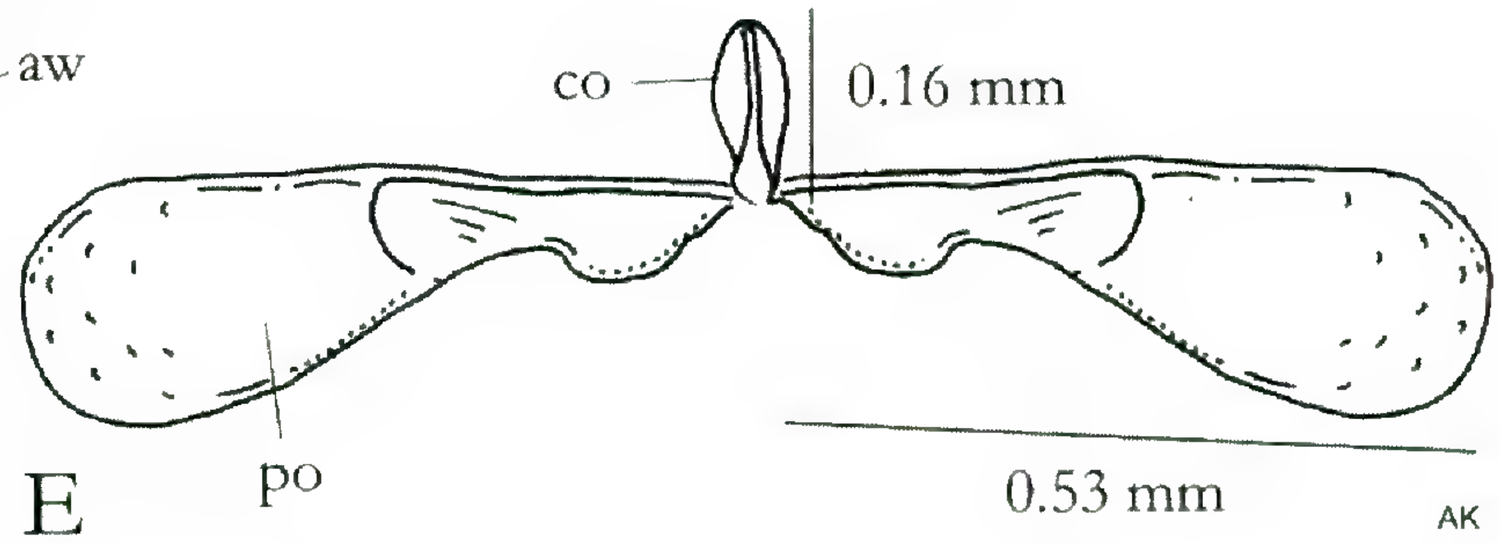


FIG. 6. *Matelea torulosa* Krings: **A,** habit; **B,** flower—note corolla lobes marginally thickened at the base, concave ("scooped-out") and forming a distinct pit (arrowed); **C,** stylar head appendage; **D,** gynostegial corona—note long, parallel anther wings; **E,** pollinarium, caudicle shape approximate. Based on *Marcano [Jiménez] 4096* (US). aw = anther wings; Ci = interstaminal gynostegial corona; cl = corolla lobes; co = corpusculum; Cs = staminal gynostegial corona; po = pollinium; ta = terminal appendage of stylar head.

chomes ca. 0.07 mm long, eglandular sharp trichomes ca. 0.2 mm long, predominantly antrorse, some retrorse, sparser than glandular-capitate trichomes; pedicels 4.5–6.1 × 0.4 mm, densely pubescent, glandular-capitate trichomes ca. 0.07 mm long, eglandular sharp trichomes ca. 0.18 mm long, predominantly antrorse or antrorse appressed. Calyx 5-lobed, lobes lanceolate or lance-ovate, ca. 1.8 × 0.8 mm, apices obtuse, margins entire, scattered pubescent, glandular-capitate trichomes to 0.07 mm long, eglandular sharp trichomes to 0.2 mm long; colleters lacking. Corolla subrotate, bases subcampanulate, tube 0.9 × 1 mm, 5-lobed, lobes imbricate in bud (not dextrorse), linear-lanceolate, 4.5–5 × 1.3–1.6 mm, apices obtuse, margins entire, marginally thickened at the base on each side, scooped-out and forming a distinct pit near the base, otherwise plane, adaxial surface papillate, abaxial surface glabrous or with a few, eglandular sharp trichomes ca. 0.2 mm long. Faucal annulus (corolline corona or Ca) indistinct. Gynostegial corona of fused staminal (Cs) and interstaminal (Ci) parts, Cs rising to meet the lower portion of the anther, rising seg-

ment scallop-shaped in outline, ca. 0.5 mm tall, not lobed on either side, yet exhibiting a smaller segment immediately in front, margins somewhat undulating to entire, Ci unlobed; anther wings parallel, nearly touching, well-developed toward the center of the stylar head, ca. 0.4–0.5 mm long, the vertical segment immediately subtending the corpusculum ca. 0.2 mm long, slightly longer than the corpusculum or as long; laminar dorsal anther appendages (Cd) absent. Pollinarium: corpuscula dark reddish-brown, ca. 1.8–1.9 mm long; pollinia borne horizontally, ovate, ca. 0.37 × 0.25 mm. Stylar head with a terminal appendage, appendage capitate ("door knob-shaped"), ca. 1-1.1 mm tall, apex ca. 1 mm broad. Follicles unknown.

Distribution.—Apparently endemic to the Dominican Republic [known only from the type].

Etymology.—The epithet refers to the capitate, door knob-like terminal appendage of the stylar head.

Discussion.—The appendage is among the shortest of the four species bearing them in Hispaniola. Only *Matelea corynephora* (Fig. 1) exhibits an appendage similarly broader at the apex than at the base, but the appendage is much longer than in *M. torulosa* and clavate. The two species also differ in a number of additional floral characteristics, such as the morphology of the gynostegial corona. The other appendaged species—*M. pauciflora* (Fig. 3) and *M. rhynchocephala* (Fig. 5)—exhibit terminal appendages that are narrower at the apex than at the base.

ACKNOWLEDGMENTS

I thank the curators and staff of the following herbaria for searching, or providing access or loans of their collections: B, BG, BH, BKL, BM, BOLO, BR, BREM, BSC, BUF, C, CGE, COLO, CR, DUKE, E, F, FI, FLAS, FR, FTG, G, GH, GOET, H, HAC, HAJB, HBG, IA, IJ, ISC, JBSD, JE, K, LD, M, MICH, MIN, MO, MSU, NEU, NSW, NY, O, OXF, P, PH, RSA, S, U, UC, UPS, US, USF, TUR, WILLI, WU, Z. I also thank Roxana Yockteng for her kind assistance during, and subsequent to, a visit to P. The North Carolina State University Libraries Inter-Library Loan Service was instrumental in obtaining necessary titles not held in the collections. Alain Liogier and an anonymous reviewer provided thoughtful reviews of a previous version of the manuscript.

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Book Review

Anthony Huxley. 2005. **Green Inheritance: The WWF Book of Plants**.(ISBN 0-520-24359-5, pbk.). The University of California Press, Berkeley, CA 94704, U.S.A. (**Orders:** California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A. Tel: 609-883-1759; Fax 609-883-7413; www.ucpress.edu). $29.95, 192 pp., 234 color, 9" × 10 1/2".

Why is environmental conservation important? If you have ever asked this question, this book will provide your answer. Focusing on the "green mantle" of plant life that surrounds us, the author shows the reader how conservation of the environment is integral to human survival. Color photographs and illustrations, including botanical illustrations from the collection at Kew Gardens, complement the clear writing style of the late Mr. Huxley, a prolific writer and an editor at *Amateur Gardening*. In this book, Mr. Huxley reminds us that "Without plants, animal life could not exist." From the very beginning, plants have acted as the "life support systems" of the planet, providing human and animal life with protection, nourishment, and even the air we breathe. It was the emergence of green plants that changed the poisonous primeval atmosphere into today's breathable oxygen-bearing atmosphere. In Chapter 2, "Guardians of the Environment", the role of plants in protecting the air we breathe, preventing soil erosion, protecting us from harmful radiation, fixing nitrogen in the soil, stabilizing the climate, and producing rain is discussed. The role of cultivated plants in providing us with food and spices is celebrated, as well as the problems resulting from modern agricultural techniques. The 5,000-year history of "green medicine" is detailed from traditional herbal cures to modern drug discovery efforts and the resurgence of herbal medicine. An important section on the conservation of medicinal plants is also included. In a chapter titled "Plants and Society" the importance of plants in our everyday lives and in the lives of other cultures is discussed. Mr. Huxley devotes an entire chapter to the roles of *in situ* conservation, such as land reserves, and *ex situ* conservation, such as modern bio-engineering and gene banks, in protecting our resources and feeding a hungry planet. The author reminds us throughout the book that "We are squandering this inheritance in ignorance, in thoughtless impatience and greed, failing to appreciate the value of what we destroy." The last chapter is appropriately titled "Saving the Plants that Save Us" and summarizes the environmental problems that are depleting plant life on our planet, as well as solutions. The primary approaches to saving our "green inheritance" include halting environmental degradation, rehabilitating land, and conserving the pristine natural and semi-natural vegetation that still remain. Mr. Huxley does not sugar-coat the issue, he acknowledges the difficulty of getting nations to work together, as well as the role that economic disparity plays in the battle. But, he paints a beautiful picture of the reward, "Besides thus providing for our physical needs, plants can also provide solace for the mind. They are endlessly fascinating, exciting, wonderful- even fabulous is not too strong a word, and they are diversely beautiful too."—*Marissa Oppel, MS, Collections and Research Assistant, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

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NEW COMBINATIONS IN THE GENUS *CYMOPTERUS* (APIACEAE) OF THE SOUTHWESTERN UNITED STATES

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ABSTRACT

Preparation of the Apiaceae for Bolack San Juan Basin Flora has necessitated the following new combinations: *Cymopterus breviradiatus*, *C. davidsonii*, *C. glomeratus* var. *fendleri*, and *C. sessiliflorus*.

RESUMEN

La preparación de las Apiaceae para la Flora de Bolack San Juan Basin ha necesitado las siguientes combinaciones nuevas: *Cymopterus breviradiatus*, *C. davidsonii*, *C. glomeratus* var. *fendleri*, y *C. sessiliflorus*.

In revising *Cymopterus* Raf. (Apiaceae) of the greater Four Corner's region for the San Juan Flora (Heil et al.), it has become necessary to make the following nomenclatural innovations. The aforementioned treatment represents a continued reliance on characters of the fruit and of vegetative morphology (Mathias & Constance 1944–45; Cronquist et al. 1997). Recently, several phylogenetic analyses of nuclear (ITS) and plastid (*rps*16 intron) sequences (Downie et al. 2002; Sun & Downie 2004; Sun et al. 2004) have defined a group, likely monophyletic, of western North American apioids. Genera include *Aletes* J.M. Coult. & Rose, *Cymopterus* [here circumscribed to include *Oreoxis* Raf., *Pseudocymopterus* J.M. Coult. & Rose, and *Pteryxia* (Nutt. ex Torr. & A. Gray) J.M. Coult. & Rose], *Harbouria* J.M. Coult. & Rose, *Lomatium* Raf., *Musineon* Raf., *Neoparrya* Mathias, *Oreogenia* S. Wats., *Oreonana* Jeps., *Podistera* S. Wats., and *Shoshonea* Evert & Constance. Thus far the molecular trees are poorly resolved with the basal branches containing several to many polytomies, thus obscuring relationships among terminal groups. A number of terminal clusters make sense to one steeped in western umbels while others seemingly defy logic. It is hoped that additional sequence data will provide sufficient insight into the evolution of the western apioides so that a stable classification can be established.

Cymopterus breviradiatus (W.L. Theob. & C.C. Tseng) R.L. Hartm., comb. & stat. nov.
BASIONYM: *Aletes macdougalii* J.M. Coult. & Rose subsp. *breviradiatus* W.L. Theob. & C.C. Tseng, Brittonia 16:306, fig. 6. 1964.

The genus *Aletes* is defined by its laterally flattened (versus terete to dorsally flattened) fruit. This lateral compression is prominent in the type species, *A. acaulis* (Torr.) J.M. Coult. & Rose and its presumed closest relatively, *A. humilis* J.M. Coult. & Rose. None of the three taxa of *Aletes* for which nomenclatural innovations are here made have fruit that are flattened laterally. Although molecular studies may eventually show that this is a fickle character, it is one that has been relied upon traditionally.

Based on gestalt and technical features of the fruits and leaves, *Cymopterus breviradiatus* is extremely similar to *Cymopterus sessiliflorus* (Theobald et al. 1964) despite the fact

that the two taxa do not group near one another based on molecular data (Fig. 2, Sun & Downie 2004). There is ample justification for removing subsp. *breviradiatus* from subjugation to *Cymopterus macdougalii* (J.M. Coult. & Rose) Tidestrom [*Oreoxis m.* J.M. Coult. & Rose, 1913; *Aletes m.* J.M. Coult. & Rose, 1935]. The former has fruit with corky-thickened wings whereas *C. macdougalii* has weakly developed, thin wings. *Cymopterus beckii* S.L. Welsh & Goodrich appears virtually identical to *C. macdougalii* morphologically. This is reinforced thanks to the number of collections of each that have been amassed in recent years. Consequently the former is treated as a synonym of *C. macdougalii*. Furthermore, as sequence data indicate (Figure 2, Sun & Downie 2004), *C. macdougalii*, *C. (Pteryxia) davidsonii*, and *C. beckii* group with *C. lemmonii* (Coult. & Rose) R.D. Dorn [*Pseudocymopterus montanus* J.M. Coult. & Rose]. *C. davidsonii* strongly resembles *C. macdougalii* morphologically and they may represent sister taxa.

Cymopterus davidsonii (J.M. Coult. & Rose) R.L. Hartm., comb. nov. BASIONYM: *Aletes? davidsonii* J.M. Coult. & Rose, Contr. U.S. Natl. Herb. 7:107. 1900. *Pseudocymopterus davidsonii* (J.M. Coult. & Rose) Mathias, Ann. Missouri Bot. Gard. 17:282, 316. 1930. *Pteryxia davidsonii* (J.M. Coult. & Rose) Mathias & Constance, Bull. Torrey Bot. Club 69:248. 1942.

This species was most recently treated in *Pteryxia* (Mathias & Constance 1944-45) and tentatively attributed to *Pseudocymopterus* (Cronquist et al. 1997).

The reader is referred to comments provided under *Cymopterus breviradiatus*.

Cymopterus glomeratus (Nutt.) DC. var. **fendleri** (A. Gray) R.L. Hartm., comb. & stat. nov. BASIONYM: *Cymopterus fendleri* A. Gray, Mem. Amer. Acad., n.s. 2. 4:56. 1849.

Specific epithet: *Cymopterus glomeratus* (Nutt.) DC., Prodr. 4:204. 1830. BASIONYM: *Thapsia glomerata* Nutt., Gen. N. Amer. Pl. 1:184. 1818, for which *Cymopterus acaulis* Raf., Herb. Raf. 2:40. 1833, is illegimate and superfluous (nom. nov. for *Selinum acaule* Pursh, Fl. Amer. Sept. 2: 732, 1813, non Cav., 1799; International Plant Names Index 2005).

Cymopterus fendleri long has been treated as distinct from the related *C. glomeratus* (*C. acaulis*; Mathias & Constance 1944–45) or as a variety of it (Cronquist 1997 et al.; Goodrich 2003). A recent study (Sun et al. 2005) using principal component analyses failed to discriminate among the five varieties recognized by Goodrich (2003). Despite this lack of resolution, the above combination is made for botanists, including myself, wishing to recognize var. *fendleri*.

Cymopterus sessiliflorus (W.L. Theob. & C.C. Tseng) R.L. Hartm., comb. nov. BASIONYM: *Aletes sessiliflorus* W.L. Theob. & C.C. Tseng, Brittonia 16:309. 1964.

The reader is referred to comments provided under *Cymopterus breviradiatus*.

ACKNOWLEDGMENTS

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Book Review

Håkan Rydin and John K. Jeglum. 2006. **The Biology of Peatlands.** Oxford University Press (ISBN 0-19-852872-8, pbk.). Oxford University Press, 2001 Evans Road Cary, NC 27513, U.S.A. (**Orders:** 800-451-7556; http://www.oup.com/us/). $49.50, b/w figures and photographs, tables, graphs, and glossary, 343 pp., 6 1/4" × 9 1/4".

The Biology of Peatlands by authors Rydin and Jeglum is part of Oxford's Biology of Habitats series and offers readers a fantastic and comprehensive introduction to Peatlands. This is a well-illustrated book with many text-summarizing and research-related illustrations. This book would be very suitable as a textbook for classes on peatlands or as a supplemental reading for exploring wetland habitats. Additionally, this title could also be a beneficial reference text for classes such as agronomy, hydrology or forestry.

The book chapters flow well from one to another in a logical order building on previous chapters' information. Chapter topics include (1) Peatland habitats, (2) Diversity of life in peatlands, (3) Adaptations to the peatland habitat, (4) Sphagnum - the builder of boreal peatlands, (5) Peat and organic soil, (6) The peat archives, (7) Peatland succession and development, (8) Hydrology of peatlands, (9) Nutrients, light, and temperature, (10) Peatland patterns and landforms, (11) Peatlands around the world, (12) Productivity and carbon balance and (13) Uses, functions, and management of peatlands.

The text is very readable and is accompanied by many supportive illustrations, graphs and charts. The authors' beginning chapters provide an introduction to terminology associated with peatlands which will help the reader both distinguish potentially confusing terminology and determine the relationship of peatland to other wetlands types. These opening chapters also give the reader an overview of common plants and animals associated in peatlands as well as special adaptations of these organisms to living in various peatland types. Chapter four focuses specifically on the life cycle, morphology, physical attributes, chemical attributes and the colonization ability of Sphagnum mosses.

All chapters are steeped with references to pertinent scientific studies. These references allow readers to learn more about methodology, data and results from such studies. The middle chapters of the book focus on peatland organic soils, hydrology including peat physical and chemical properties, peat as historical, fossil "archives," detailed explanations of the processes involved in peatland succession and development, descriptions of water flows, balances in peatland types and the roles of nutrients, light and temperature in peatlands. The hydrology chapter includes a wonderful discussion of the variations in water chemistry along bog-rich fen gradients. This discussion contains information from recent research studies on the subject and includes a summary chart of the surface water chemistry of various peatland sites. Within chapter nine is a wonderful example of research regarding forestry uses of peatlands in a discussion of "nutrients after drainage for forestry"; again the authors have presented many supportive research references in the discussion.

The final chapters discuss peatland patterns and formations, peatlands around the world, peatland production and carbon balance, peatland uses, peatland function and peatland management. These final chapters use the information from previous chapters to explain many areas of peatland ecology and hydromorphology. The peatland landforms section has a helpful subsection on mire descriptions and classifications at different scales including a summary table and detailed description of mire features, sites and types. Many descriptive photographs accompany this discussion of mire types. The authors have focused this text on northern peatlands, but they do include sections contributed from other authors on peatlands in Argentina, New Zealand, and southeast Asia. Peatland biomass and productivity as well as peatland uses, function and management, tie together much of what has been covered in previous chapters with many applications to other related fields. The productivity information is loaded with methodology on how to examine peatland productivity and various parts of the carbon cycle within peatlands, as well as a presentation of information on peat accumulation and limitations in accumulation. The last chapter has many applications of peatland products, management and information relating to peat sustainability and uses in fields such as forestry, fuel use, horticulture and as a de-pollution substrate.

The Biology of Peatlands by authors Rydin and Jeglum provides a comprehensive overview to peatlands biology, ecology and peatland types. This book is full of supportive black and white illustrations, charts, tables and references to research studies. *The Biology of Peatlands* would serve as an excellent textbook for classes focusing on peatlands, wetland habitat types, and related classes where peatland products may be of interest.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

SIX NEW SPECIES OF *SPHAGNUM* (BRYOPHYTA: SPHAGNACEAE) FROM NORTH AMERICA

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ABSTRACT

Sphagnum mcqueenii, S. kenaiense, S. bergianum, S. beothuk, S. sitchense, and **S. talbotianum**, are described and illustrated as new species for North America.

RESUMEN

Se describen se ilustran como especies nuevas de Norte América, **Sphagnum mcqueenii, S. kenaiense, S. bergianum, S. beothuk, S. sitchense,** y **S. talbotianum.**

INTRODUCTION

Extensive field work in North America in recent years has revealed a number of new species of *Sphagnum*, mostly in more remote and poorly collected areas. Six of those species are described in this paper. Four are from Alaska, one from Newfoundland, one from both Newfoundland and Alaska and a sixth species from several states and Canadian provinces in northeastern North America.

Sphagnum mcqueenii Andrus, sp. nov. (**Figs. 1–6**). TYPE: U.S.A. NEW HAMPSHIRE: Monroe Co.: Town of Nottingham, Pawtuckaway State Park, Dead Pond, extensive poor fen, 18 Sep 1994, *Andrus 9070* (HOLOTYPE: DUKE; ISOTYPES: BING, NY). *Sphagnum* sect. *Cuspidata*.

Planta staturam mediam attingens, flava vel brunnescens, capitulum apicem planumevolventi, gemma terminali praedito. Cortex caulinus e 1–2 stratis cellularum subdistinctarum tenuibus parietibus praeditarium compositus. Folia caulina aequilaterali-triangularia, 0.75–1.0 mm lata, 0.8–1.1 mm longa, late marginata, in regione apicali efibrillosa vel fibrillosa, plerumque in parte media superna in superficie concave poris vel in membranis hiatibus praedita, cellulis hyalinis plerumque in dimidio inferiore septatis, apice plusminusve obtuso. Folia ramulina ovato-lanceola, 0.5–0.85 mm lata, 1.6–2.1 mm longa, in superficie convexa cellulis hyalinus poros apicales 0–1 et plerumque pseudopores habentibus, in concave in angulis cellularum et interdum commissuras seus poris rotundis usque ad 12, 4–8 μm diametro praedita.

Plants robust and weak-stemmed; yellow to light brown; capitulum typically flat- topped and with a ± conspicuous terminal bud. **Stems** light green; cortex in 1–2 layers of moderately differentiated thin-walled cells. **Stem leaves** equilateral- triangular, 0.75–1.0 mm wide by 0.8–1.1mm long, usually spreading, apex obtuse, hyaline cells usually septate in lower half of leaf and efibrillose (or fibrillose near apex). **Branches** unranked, ± straight, branch leaves moderately elongated at distal end. **Branch leaves** ≤ 2.1 mm long, ovate-lanceolate, undulate and sharply recurved when dry; hyaline cells on convex surface with 0–1 apical pores and often with pseudopores, concave surface with up to 12 round wall-thinnings in cell angles and sometimes along commissures; chlorophyllose cells triangular in transverse section and just enclosed on the concave surface. **Sexuality** unknown.

Distribution.—Western Hemisphere Atlantic; known to date from Maine, New Hamp-



FIG. 1. *Sphagnum mcqueenii*. Habit.

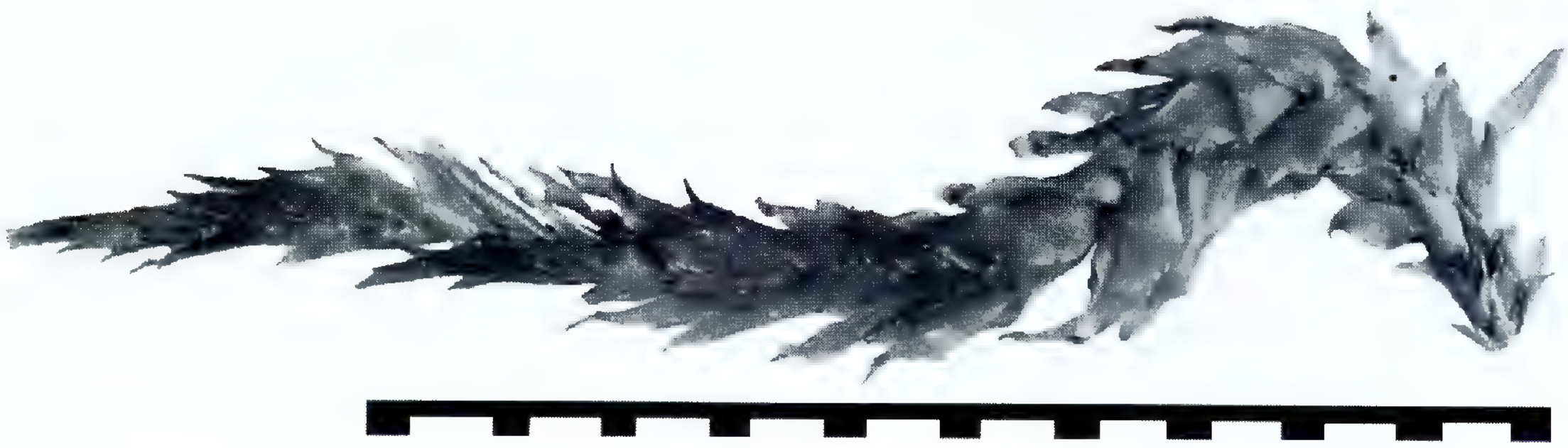


FIG. 2. *Sphagnum mcqueenii*. Spreading branch.

shire, Pennsylvania, and Vermont from the U.S.A. and Nova Scotia and Newfoundland in Canada.

Identification.—*Sphagnum mcqueenii* can be separated from *S. cuspidatum* Hoffm. by its enclosed chlorophyll cells, obtuse stem leaves and the relatively short, recurved and broad (width : length ratio > 0.3) branch leaves. *Sphagnum viride Flatberg.* will differ in having branch leaf chlorophyll cells not reaching the concave surface and pointed stem leaves. Both *S. cuspidatum* and *S. viride* are also smaller and slenderer plants. *S. pulchrum* (Braith.) Warnst. has strongly 5-ranked branch leaves, more pointed stem leaves and more well-enclosed branch leaf chlorophyll cells. Wet-growing forms of *S. pulchrum* will also not have branch leaves elongated at the distal end of the branches, a characteristic of the more "aquatic" Cuspidata species. The other "aquatic" Cuspidata with which *S. mcqueenii* can occur are *S. torreyanum* Sull.and *S. atlanticum* Andrus. Both of these are larger plants and have longer branch leaves (> 2.1 mm). They also have stem leaves more appressed to the stem than *S. mcqueenii*, in which the stem leaves are often spreading.

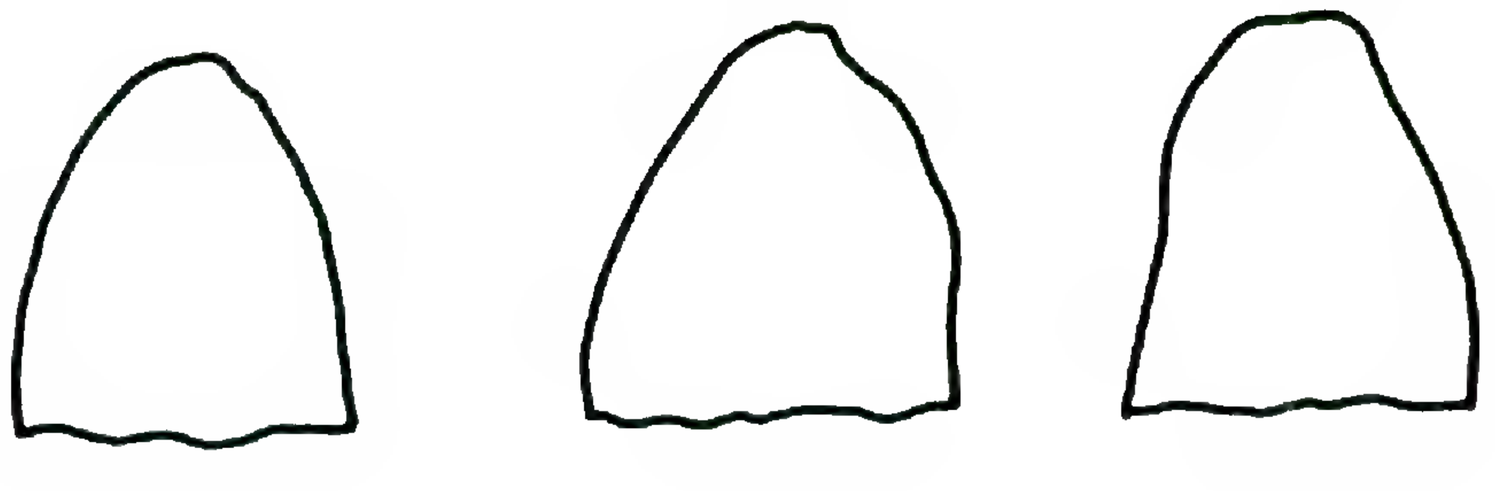
Ecology.—Habitat preferences not well known but it has so far been collected in poor fen habitats with floating mats, wet carpets and wet peaty depressions. It was quite abundant in the New Hampshire type locality, where it occurred in the moat at the bog margin associated with *S. torreyanum, S. atlanticum, S. cuspidatum* and *S. flexuosum* Dozy. & Molk.

Etymology.—The namesake of this species is the late Cyrus McQueen, a good friend and fellow sphagnophile, who led me to the type locality.

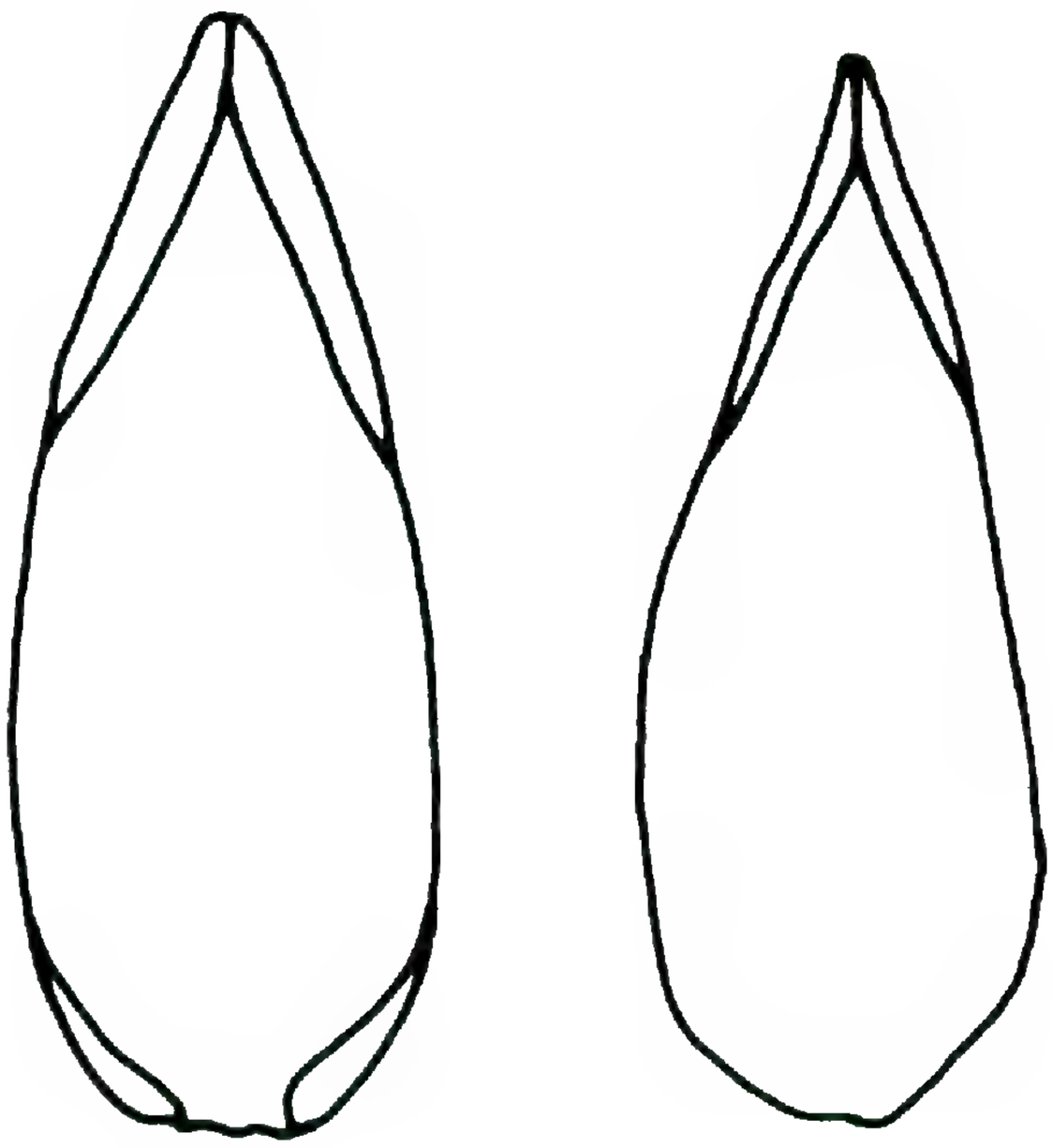
Additional collections examined: **CANADA. Newfoundland:** N of Pouch Cove, *Andrus 10309* (BING); Winterland, *Andrus 10422, 10423, 10439* (BING, DUKE); N of Harbour Breton, *Andrus 10632* (BING); Lark Harbour, *Andrus 10683* (BING, DUKE). **NOVA SCOTIA. Guysborough Co.:** *Schofield & Maass 3315* (DUKE). **U.S.A. MAINE:** Acadia National Park, *Little 16* (BING). **Sagahadoc Co.:** *Allen 27060* (DUKE). **PENNSYLVANIA. Monroe Co.:** *Andrus & Damman 6641* (BING). **VERMONT. Windham Co.:** *McQueen s.n.*, 19 Nov 1998 (BING, DUKE).

Sphagnum kenaiense Andrus, sp. nov. (**Figs. 7–12**). TYPE: U.S.A. ALASKA. Kenai Peninsula Co.: Kenai Peninsula, Soldotna, Headquarters Lake large poor fen complex surrounding lake, 17 Aug 2004 (HOLOTYPE: DUKE; ISOTYPES: BING, NY). *Sphagnum* sect. *Cuspidata.*

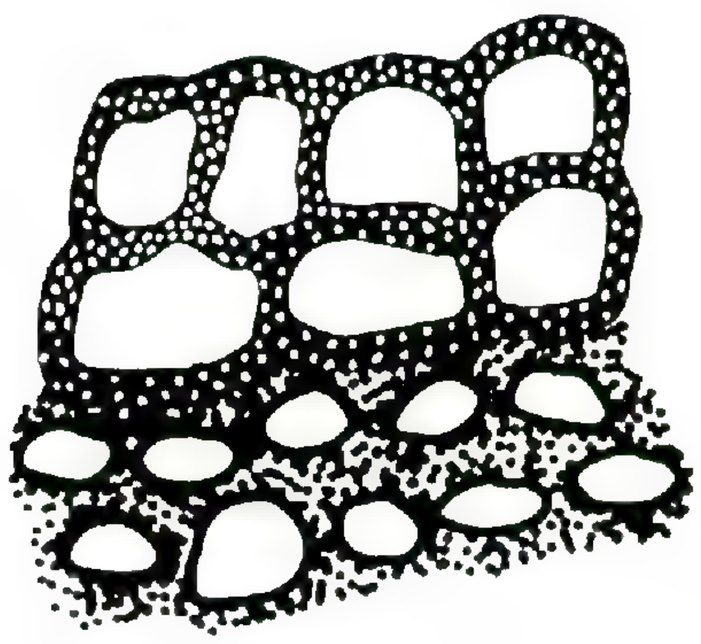
Planta parva caule debili, pallide brunnea vel aetate aurea, capitulo plano; cortex caulinus parietibus tenuibus, tantum leniter dilatatus. Folia caulina ad caulem appressa, lingulata, ovato-lingulata vel triangulata, aequa vel minora quam 0.9 mm longa, apice obtuso atque saepe eroso vel lacerato. Rami tantum leniter 5-ordinati vel 5-seriata, in apice distali rameali vix elongati. Fasciculus ramulinus e ramulis 2 patentibus atque 2–3 pendentibus compositus. Folia ramulina 1.1–1.3 mm longa, ovata, rigentia, in statu sicco leniter undulata atque subrecurva,



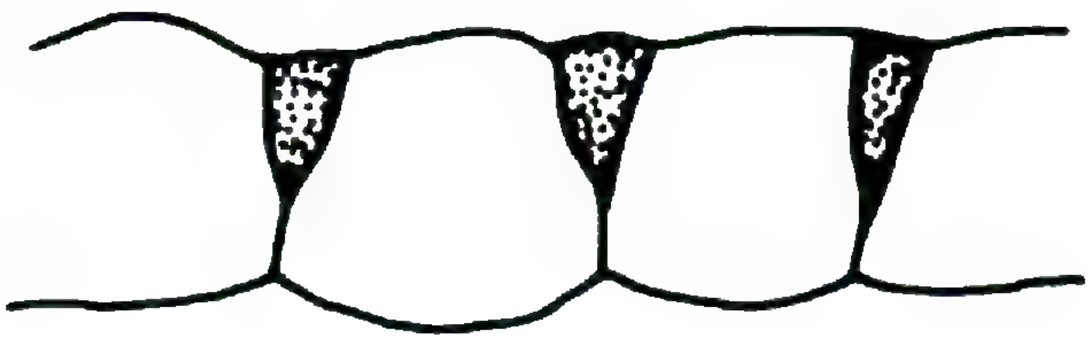
4



3



5



6

FIGS. 3–6. *Sphagnum mcqueenii*. **3.** Branch leaves. **4.** Stem leaves. **5.** Stem cortex cross section. **6.** Branch leaf cross section.

cellulis hyalinis in parte mediana perbrevibus atque latis (ratione arithmetica latitudinis usque longitudinis 0.3–0.4) et in superficie convexa in parte folii inferiore saepe apicaliter poro magno atque/usque 6 poris liberis et parte apicali saepe margines cellulares secus peudoporis instructa, in superficie concava ad terminos cellulares atque angulos areis parietum tenuium magnis rotundis interdum inconspicuuis vel nullis praedita; cellulae chlorophylligerae in section transversali triangulares, typice in superficie bene inclusae.

Plants small and weak-stemmed; pale brown to golden brown; capitulum flat-topped and

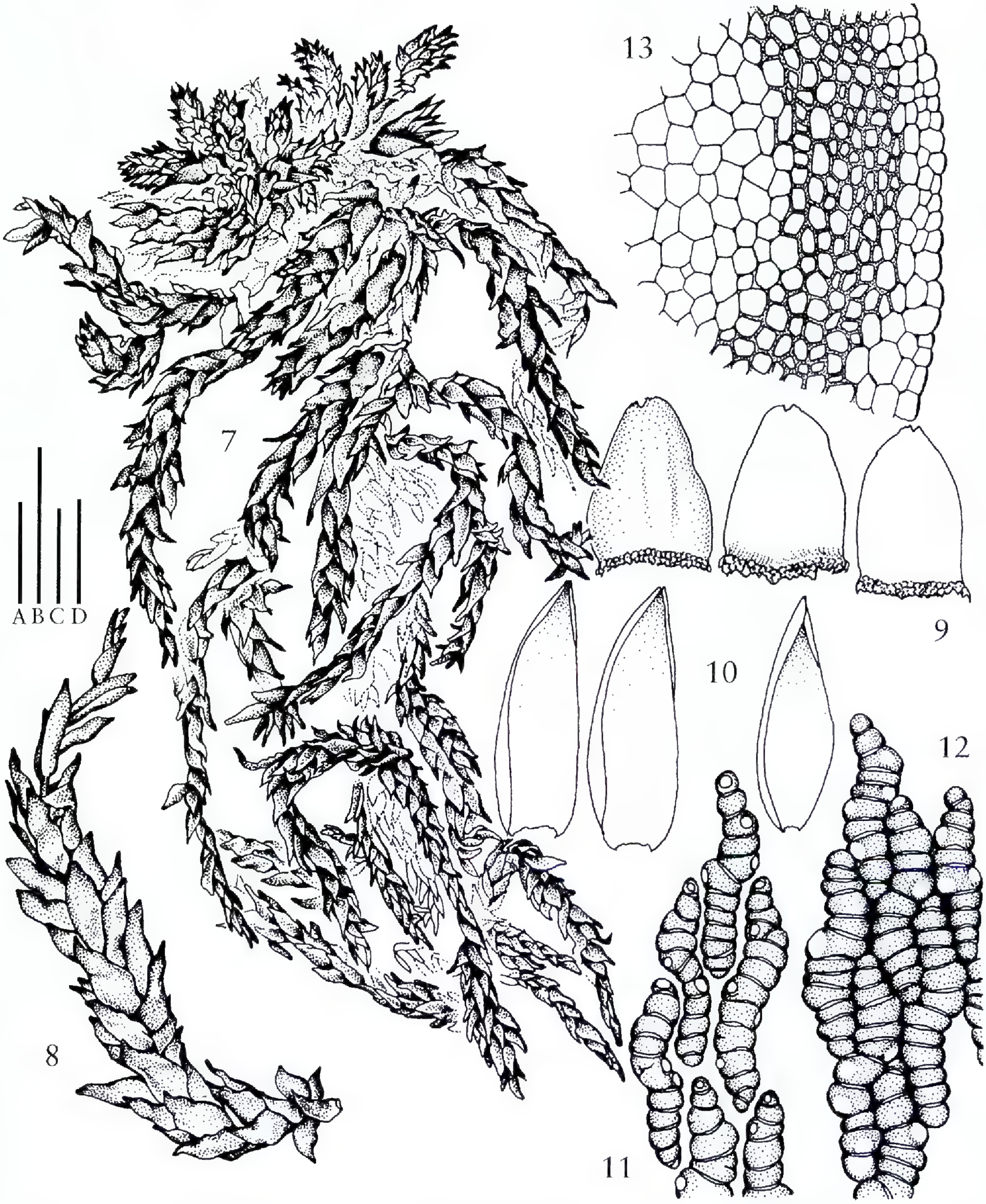


FIG. 7–13. *Sphagnum kenaiense*. **7.** Habit. **8.** Branch. **9.** Stem leaves. **10.** Branch leaves. **11.** Branch leaf convex surface. **12.** Branch leaf concave surface. **13.** Stem section. Scale bars: A = 2 mm, 7; B = 2 mm, 8; C = 0.5 mm, 9–10; D = 50 µm, 11–13.

only weakly 5-radiate. **Stems** pale yellow; stem cortex moderately well-differentiated but not much enlarged. **Stem leaves** appressed to stem; lingulate, ovate,to triangular; equal to or less than 0.9 mm long; apex obtuse and often erose to lacerate. **Branches** with leaves unranked to 5-ranked, leaves not much elongated at distal branch tip. **Branch fascicles** with 2 spreading and 2–3 pendent branches. **Branch leaves** ovate, 1.1–1.3 mm long, stiff,

weakly undulate and slightly recurved when dry; hyaline cells in mid-region quite short and broad (width:length = 0.3–0.4), in lower 1/2 of leaf on convex surface often with 1 large pore apically and/or up to 6 free pores, in apical region often with pseudopores along the cell margins; on concave surface with large round wall-thinnings in the cell ends and angles (these sometimes faint or absent); chlorophyllose cells triangular in transverse section and typically well-enclosed on concave surface. **Sexuality** unknown.

Distribution.—South-Central and Western Alaska.

Identification.—Within its range, *S. kenaiense* may be confused with *S. angustifolium* (Russow) C. Jens., *S. balticum* (Russow) C. Jens.) and *S. brevifolium* (Braithw.) Roell. *Sphagnum angustifolium* in the field has narrower ovate-lanceolate branch leaves. Microscopically *S. angustifolium* has a poorly differentiated stem cortex, chlorophyll cells not well-enclosed and narrower branch leaf hyaline cells. *Sphagnum balticum* has narrower branch leaves and typically only one hanging branch, with stem leaves markedly spreading. Microscopically the branch leaf hyaline cells are also narrower. *Sphagnum brevifolium* has stem leaves that are apiculate to acute and ovate-lanceolate branch leaves. It also has narrower hyaline cells in its branch leaves than *S. kenaiense*.

Ecology.—*Sphagnum kenaiense* occurs in poor to medium fens, often of a sedge dominated nature. It typically forms sprawling patches in hollows, often over bare peat.

Etymology.—The species epithet *kenaiense* is after the Kenai Peninsula where the species was found.

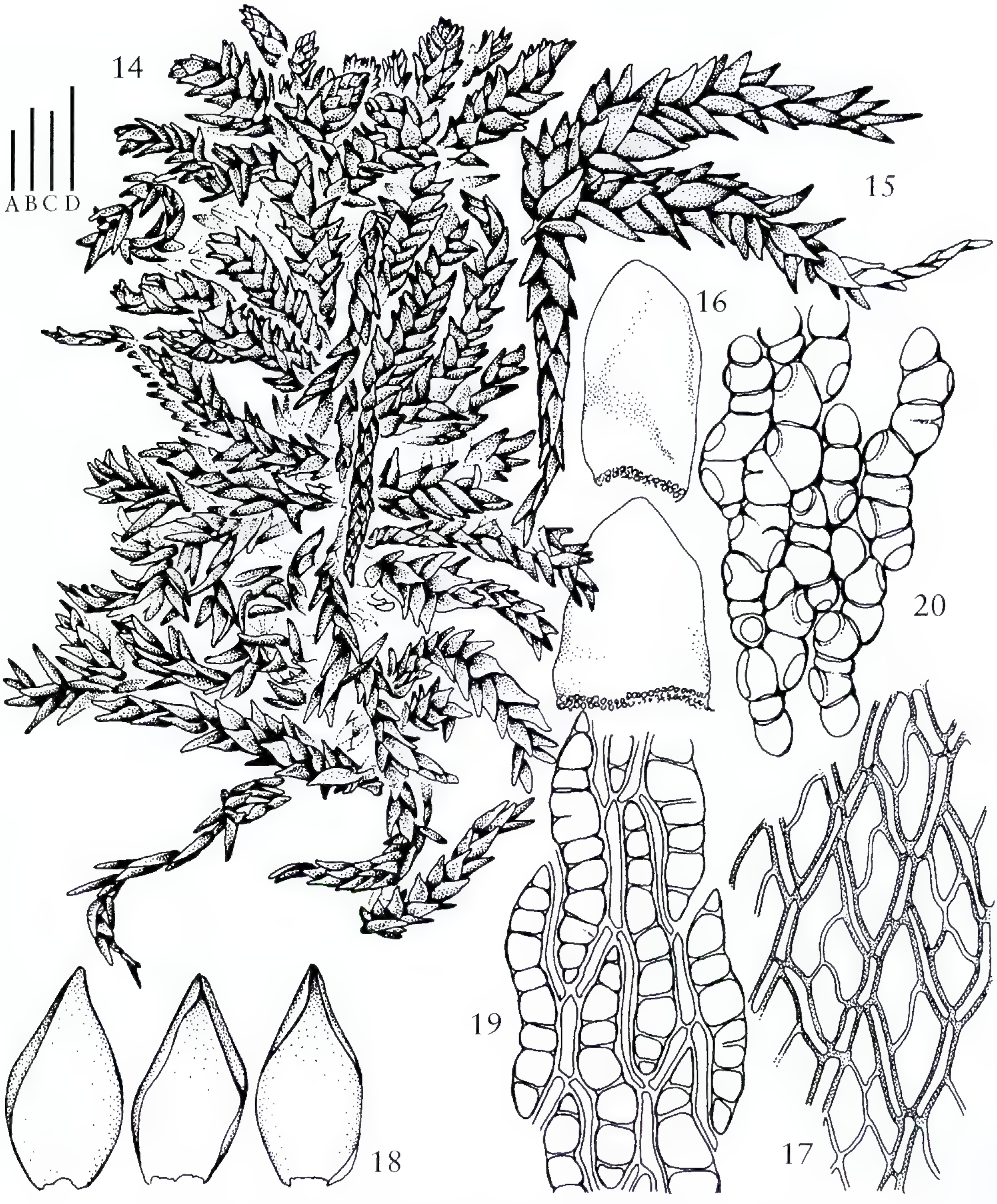
Additional collections examined: **U.S.A. ALASKA:** King Salmon, *Andrus 9306* (BING, DUKE); Selawik, *Schofield 121,733* (BING); Anchorage, Campbell Airstrip fen, *Andrus 8448* (BING, DUKE); Kenai Peninsula, Milepost 100 on Seward Hwy., *Andrus 8752* (BING, DUKE, NY).

Sphagnum bergianum Andrus, sp. nov. (**Figs. 13–19**). TYPE: U.S.A. ALASKA. Kenai Peninsula Co: Kenai Peninsula, Soldotna, Headquarters Lake, extensive poor fen complex at lake margin, 17 Aug 2004, *Andrus 10020* (HOLOTYPE: DUKE; ISOTYPES: BING, NY). *Sphagnum* section *Acutifolia*.

Planta quoad staturam mediocris vel robusta, capitulo plus minusve in apice plano magnoque, omnino atro-fusco, centro capituli aurato, in statu vivo saturate rubritingenti, in statu sicco nitore roseolo-purpurascenti praedito.Caulis atro-fuscus, cellulis corticalibus superficialibus eporosis. Folia caulina late triangulari-lingulata, 1.15–1.25 × 0.8, in apice subobtusa vel late obtusa, limbo ad basem modice dilatato, cellulis hyalinis pro parte maxima 1-septatis, paucis vel multis in parte mediana 2-septatis,rhombiformibus. Rami plus minusve 5-ordinati. Fasciculus ramulinus e ramulis 2 patentibus atque 1 pendenti. Folia ramulina 1.2–1.3 × 0.65–0.75 mm, late ovata, apice involuta, cellulis hyalinis in superficie convexa numerosis rotundatis vel ellipticis poris commissuras secus instructis, in apice poris parvis gradatim usque ad basem maioribus, superficie concave eporosa, poris paucis magnis in partibus distalibus lateralibusque exceptis. Status sexualis dioicus. Sporae 26–30 µm.

Plants moderate-sized to robust, capitulum more or less flat-topped and large; dark brown overall with a golden center to the capitulum and a distinctive deep red tinge in the field which becomes a pinkish-purple sheen upon drying. **Stems** dark brown; superficial cortical cells aporose. **Stem leaves** broadly triangular-lingulate, 1.15–1.25 × 0.8, apex slightly to broadly obtuse, border moderately broadened at base; hyaline cells mostly 1-septate with a few to many 2 septate in the mid-region, shape rhomboidal. **Branches** more or less 5 ranked. **Branch fascicles** with 2 spreading and 1 hanging branch. **Branch leaves** 1.2–1.3 mm × 0.65–0.75, broadly ovate, apex involute; hyaline cells on convex surface with numerous round to elliptic pores along the commissures, these grading from small pores at the apex to large pores at the base; concave surface aporose except for a few large pores in the lower side regions. **Sexual condition** dioicous. **Spores** 26–30 µm.

Distribution.—Newfoundland and South-central Alaska.



FIGS. 14–20. *Sphagnum bergianum*. **14.** Habit. **15.** Branch fascicle. **16.** Stem leaves. **17.** Stem leaf hyaline cells. **18.** Branch leaves. **19.** Branch leaf, concave surface. **20.** Branch leaf convex surface. A = 2 mm, 14; B = 2 mm, 15; C = 0.5 mm, 16, 18; D = 50 µm, 17, 19–20.

Identification.—*Sphagnum bergianum* seems most clearly related to *S. subfulvum* Sjoers sensu lato, as described by Flatberg (1985). Both *S. subfulvum* and *S. subfulvum ssp purpureum* Flatb. are a lighter golden-brown than the quite dark brown of *S. bergianum*. Furthermore, both of these taxa have narrower stem leaves that are more acute at their apex. And neither of these taxa have distinctly 5-ranked branch leaves like *S. bergianum*. *Sphagnum bergianum* is a quite unusual looking species in the field, with its very dark brown color tinged with a deep red color. When dry this deep red becomes more purplish

but it still shows some red. This distinctive field appearance made it quite recognizable when collected in Newfoundland in 2005.

Table 1 highlights the differences between *S. bergianum* and other larger brown *Acutifolia*. Because of its similarity, *S. subfulvum* ssp *purpureum* is included for completeness even though the author has not seen any North American specimens of that taxon and believes it to be of doubtful occurrence there.

Ecology.—In the few sites where it has so far been collected, *S. bergianum* has been a hummock forming species of medium fen habitats, associated with such species as *S. warnstorfii* Warnst., *S. subfulvum*, *S. platyphyllum* (Braithw.) Warnst. and *S. fuscum* (Schimp.) H. Klinggr.

Etymology.—This species named after Ed Berg, ecologist with the US Fish and Wildlife Service, who first found this species in Headquarters Lake next to his office.

Additional collections examined: **CANADA. Newfoundland:** 9 km N of Badger, *Andrus 10646* (BING, DUKE, NY); 15 km SW of Corner Brook, *Andrus 10667* (BING, DUKE, NY). **U.S.A. Alaska:** Kenai Peninsula, Milepost 40 on Seward Hwy., *Andrus 10036* (BING, DUKE, NY).

Sphagnum beothuk Andrus, sp. nov. (**Figs. 20–25**). TYPE: CANADA. NEWFOUNDLAND: Lark Harbour, ca. 50 km NW of Corner Brook, medium rich fen, 20 m elev., *Andrus 10687* (HOLOTYPE: DUKE; ISOTYPE: BING, NY). *Sphagnum* sect. *Acutifolia*.

Planta parva vel quoad staturam mediocris, capitulo rotundato densoque atro-fusco nitore purpurascenti praedito. Caulis brunneus, cellulis corticalis superficialius eporosis. Folia caulina lingulata, 1.1–1.2 mm longa, in apice subapiculata vel maximam partem lata, erosaque vel lacerata, limbo ad basem tantem parce dilatato, cellulis hyalinis rhombiformibus, 0–1-septatis. Rami plus minusve 5-ordinati. Fasciculus ramulinus e ramulis 2 patentibus atque 1 pendenti compositus. Folia ramulina 0.95–1.3 mm longa, ovata vel ovato-lanceolata, concava, stricta vel parce subsecunda, in apice involuta, cellulis hyalinis in superficie convexa poris commissuras secus numerosis rotundatis vel ellipticis instructis, ad basem poris magnis gradatim usque ad apicem miscellaneam e poris minutis vel perpusillis (2 m, minoribus quam 0.25 partes latitudinis cellularum) compositam formantibus, superficie concava in partibus proximalibus lateralibusque poris parcis, rotundatis per cellulam instructa. Status sexualis ignotu.

Plants small to moderate-sized; capitulum rounded and dense; dark brown with a purplish sheen. **Stem** brown, superficial cortical cells aporose. **Stem leaves** lingulate, 1.1–1.2 mm long, apex slightly apiculate to mostly broad and erose to lacerate, border only slightly broadened at base; hyaline cells rhomboidal and 0–1 septate. **Branches** more or less 5-ranked. **Branch fascicles** with 2 spreading and 1 pendent branch. **Branch leaves** 0.95–1.3 mm long, ovate to ovate-lanceolate, concave, straight to slightly subsecund, apex involute; hyaline cells on convex surface with numerous round to elliptic pores along the commissures, grading from large pores at the base to a mixture of small and tiny (2 µm, less than 0.25 cell width) at the apex, concave surfacewith a few large, round pores/cell in lower side regions. **Sexual condition** unknown.

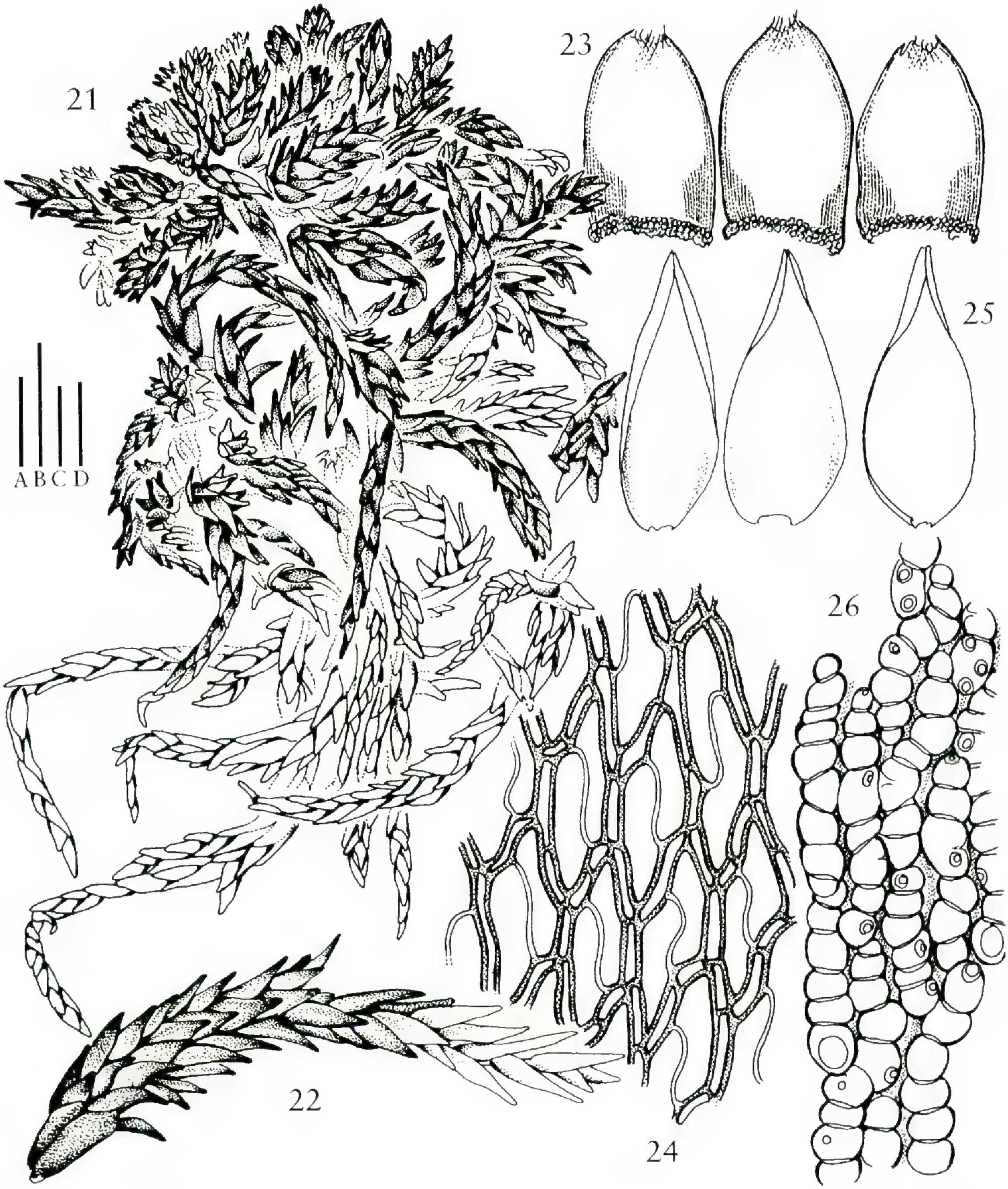
Distribution.—Known only from Newfoundland, Canada.

Identification.—In the field *S. beothuk* looks like a very dark form of *S. fuscum* except for its distinct purplish sheen. It's rather more robust than *S. fuscum* and also has 5-ranked branch leaves, which *S. fuscum* usually lacks. Microscopically, however, *S. beothuk* differs clearly in the tiny pores seen mixed in with more typical pores on the convex surface of the branch leaf at the apex. Among the known *Acutifolia* species, only the red pigmented *S. warnstorfii* has been noted with this character before.

Ecology.—*Sphagnum beothuk* forms dense hummocks similar to *S. fuscum*. It appears to be a minerotrophic species and has been collected in the same mire as *S.subfulvum*, *S. inundatum* Russow, and *S. warnstorfii*.

TABLE 1. Comparison of *Sphagnum bergianum* and related species.

Characteristic	*S. bergianum*	*S. subfulvum*	*S. subfulvum* ssp. *purpureum*	*S. subnitens*	*S. flavicomans*
Color	Dark brown with a deep red tinge	Golden-brown with a purplish gloss sometimes	Golden-brown with red tinge	Reddish-purple mixed with golden brown	Brown
Branch fascicles, spreading + hanging branches	2 + 1	2 + 1–2	2 + 1–2	2 + 1–2	2 + 1–2
Branch leaf ranking	Often 5 -ranked	Unranked	Unranked	Unranked	Often 5-ranked
Branch leaf shape	Broadly ovate	Ovate	Ovate	Ovate to ovate-lanceolate	Ovate-lanceolate
Stem leaf shape	Triangular-lingulate	Triangular-lingulate to broadly lingulate	Triangular-lingulate	Triangular to triangular-lingulate	Narrowly triangular-lingulate
Stem leaf apex	More or less obtuse	More or less acute	More or less acute	Acute to apiculate	Acute to apiculate
Stem leaf length in mm	1.15–1.25	0.9–1.3	1.3–1.4	1.3–2.7	1.5–2.0
Stem leaf hyaline cells	1–2 septate	0–1 septate	0–1 septate	0–1 septate	0–1 septate
Distribution	Newfoundland & SC Alaska	NE and NW North America	NW Europe	Eurasia, W North America & New Zealand	NE North America



FIGS. 21–26. *Sphagnum beothuk*. **21.** Habit. **22.** Branch. **23.** Stem leaves. **24.** Stem leaf hyaline cells. **25.** Branch leaves. **26.** Branch leaf hyaline cells, convex surface. A = 2 mm, 21; B = 1 mm, 22; C = 0.5 mm, 23, 25; D = 30 µm, 24, 26.

Etymology.—The Beothuk are the aboriginal people of Newfoundland.

Comments.—Several things suggest a possible hybrid origin between *S.fuscum* and *S. warnstorfii*. The tiny pores at the branch leaf tips, the purplish sheen and the 5-ranked branch leaves suggest *S. warnstorfii* and the lingulate stem leaves are a character of *S. fuscum*. Furthermore the type locality is a minerotrophic site in which both *S. fuscum* and *S. warnstorfi* also occur.



FIGS. 27–34. *Sphagnum sitchense*. **27.** Habit. **28.** Branch. **29.** Branch leaves ("b"). **30.** Stem with leaves. **31.** Stem leaf hyaline cells. **32.** Stem leaves ("s"). **33.** Branch leaf, convex surface. **34.** Branch leaf, concave surface. A = 2 mm, 27; B = 1 mm, 28, 30; C = 0.5 mm, 29, 32; D = 50 µm, 31, 33, 34.

Additional collections examined: **CANADA. Newfoundland:** Lark Harbour, *Andrus 10685, 10686, 10687* (TOPOTYPES: BING, DUKE); ca. 16 km S of jct. of Hwy 210 and Hwy 214, *Andrus 10408* (BING, DUKE).

Sphagnum sitchense Andrus, sp. nov. (**Figs. 26–33**). TYPE: U.S.A. ALASKA: Sitka Co.: Sitka, Harbor Mt., alpine area at end of road, 700 m elev., dense patch in tundra, 19 Aug 2004, *Andrus 10097* (HOLOTYPE: DUKE; ISOTYPES: BING, NY). *Sphagnum* sect. *Acutifolia*.

Planta quoad staturam parca, capitulo in apice plano, denso, luteolo atque roseolo, nitore destituto. Caulis roseolus, cellulis corticalibus superficialibus eporosis. Folia caulina anguste triangularia vel lingulato-triangularis, 1.2–1.6 mm longa × 0.6 0.8 mm lata, ratione arithmetica longitudinis usque latitudinis ca. 2:1, apice apiculato, limbo valde distincto basaliter modice dilatato, cellulis hyalinis anguste rhomboidalibus interdum 2-septatis, saepe in apice fibrillosis. Rami non 5-ordinati. Fasciculus ramulinus e ramulis 2 patentibus atque 1 pendenti compositus. Folia ramulina 1.3–1.5 mm longa, 0.5–0.55 mm lata, ovato-lanceolata, concava, stricta, in apice involuta; cellulae hyalinae in superficie convexa commissuras secus poris numerosis rotundis vel ellipticis ad basem poris magnis ellipticis gradatim usque ad apicem rotundatis quoad staturam mediocribus, in superficie concava poris magnis rotundatis paucis omnino adspersis. Status sexualis ignotus.

Plants moderate-sized; capitulum flat-topped and dense; pale yellow and pink, lacking sheen. **Stem** pink, superficial cortical cells aporose. **Stem leaves** narrowly triangular to lingulate- triangular, 1.2–1.6 mm long × 0.6–0.8 mm wide, length:width ratio ca 2:1,apex apiculate, border strong and moderately broadened basally; hyaline cells narrowly rhomboidal and 1 to occasionally 2 septate, often fibrillose apically. **Branches** not 5-ranked. Branch fascicles with 2 spreading and 1 pendent branch. **Branch leaves** 1.3–1.5 mm long and 0.5–0.55mm wide, ovate-lanceolate, concave, straight, apex involute; hyaline cells on convex surface with numerous round to elliptic pores along the commissures, grading from large elliptical pores at the base to moderate-sized round pores at the apex, concave surface with a few large round pores scattered throughout. **Sexual condition** unknown.

Distribution.—Known only from the type locality in southeast Alaska but since alpine areas in this area are poorly collected it is likely more widespread.

Identification.—Sphagnum sitchense is somewhat similar to *S. capillifolium* (Ehrh.) Hedw. But differs in a number of important ways. Its stem leaves are often narrowly triangular whereas those of *S. capillifolium* are lingulate- triangular. Branch fascicles on *S. sitchense* have 2 spreading and one hanging branch whereas those of *S. capillifolium* have 2 spreading and mostly 2 hanging branches. The stem leaf hyaline cells in *S. sitchense* are 1–2 septate while those on *S. capillifolium* are 0–1 septate. In the field *S. sitchense* has a pale red tinge and quite flat topped capitulum which contrast with the deeper red tinge and rounded capitulum of *S. capillifoilum.*

Sphagnum sitchense also bears some resemblance to *Sphagnum subnitens* but differs in the following ways. *Sphagnum sitchense* has a strongly bordered stem leaf with a few 2 septate hyaline cells while *S. subnitens* has a narrow border and hyaline cells 0–1 septate only. *Sphagnum sitchense* also lacks the metallic sheen and brown coloration that are typical of *S. subnitens.* And lastly, the branch fascicles in *S. sitchense* have only one hanging branch whereas *S. subnitens* has mostly two.

The stem leaves of *S. sitchense* are quite similar to those of *S. quinquefarium,* with which it occurred in the type locality, but the latter species has 5-ranked branch leaves and typically 3 spreading branches per fascicle.

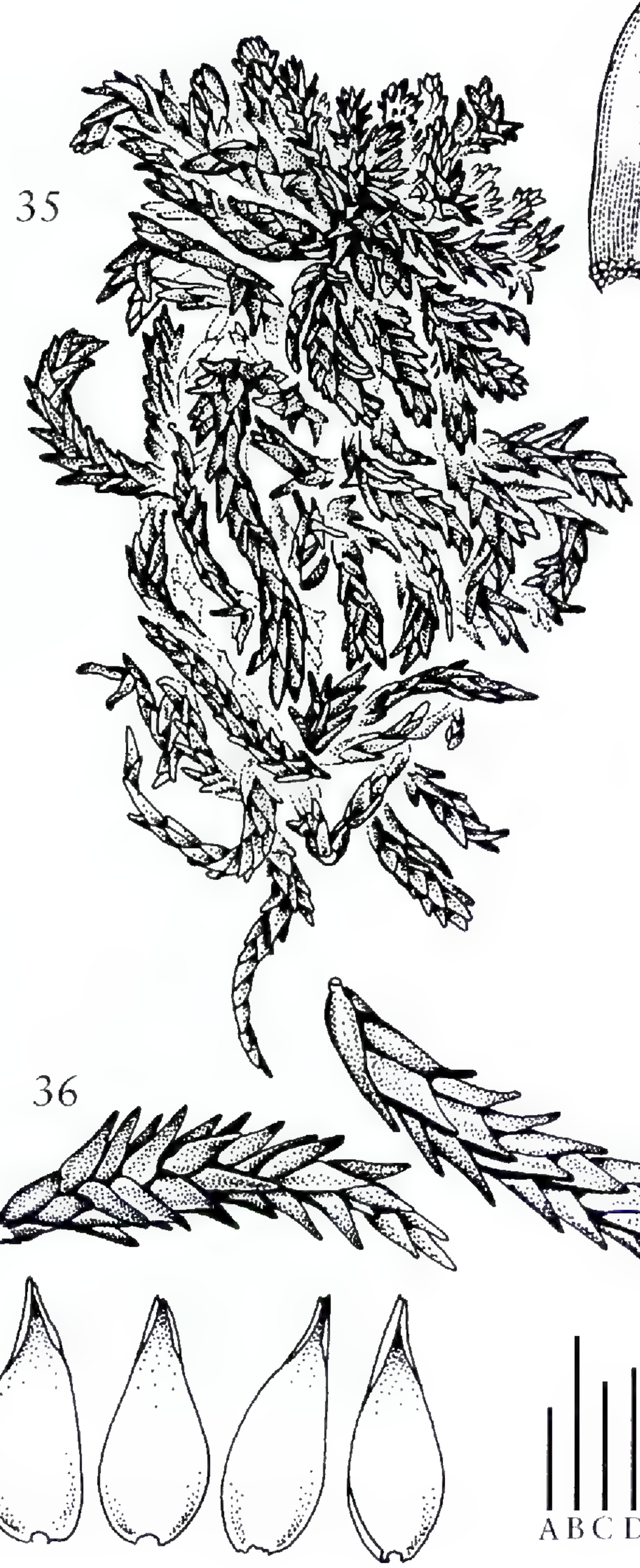
Ecology.—In the type locality, *S. sitchense* was collected several times in dense patches in the tundra. Growing similarly in the same area were *S. girgensohnii* Russow, *S. quinquefarium* (Braithw.) Warnst., and *S. compactum* D.C.

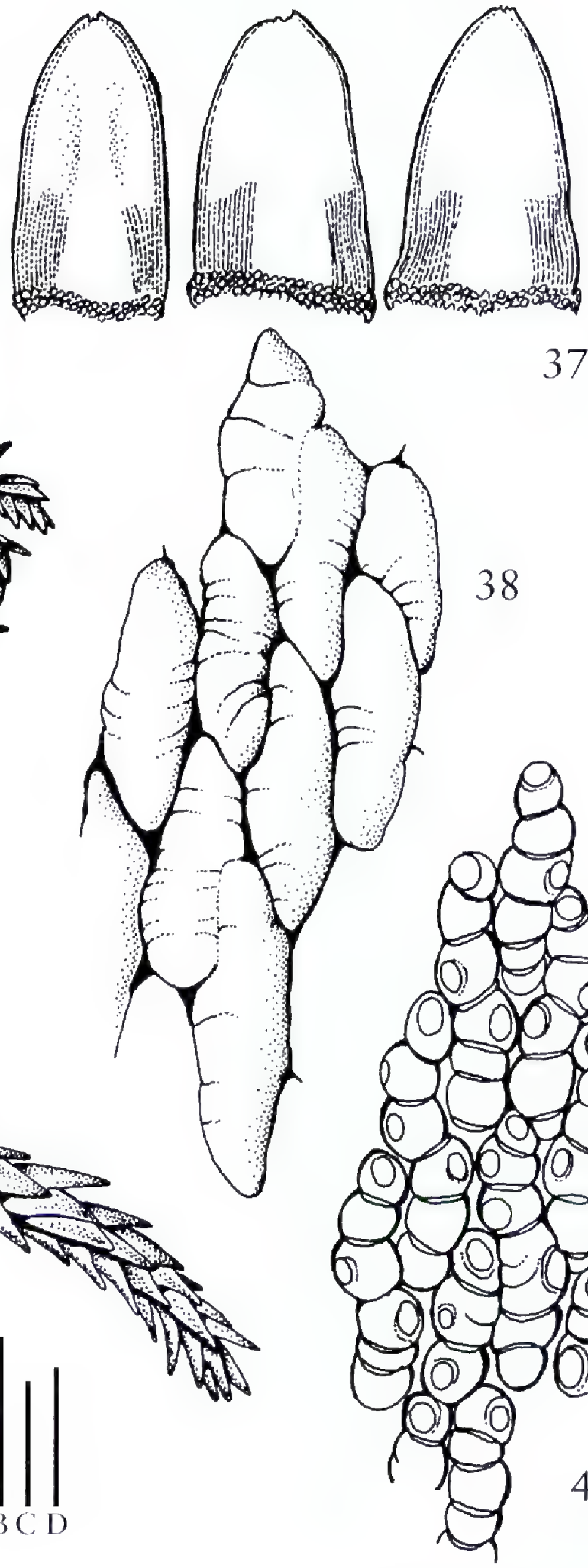
Etymology.—Sphagnum sitchense is after the type locality.

Additional collections examined: **U.S.A. Alaska:** Sitka, Harbor Mt,. *Andrus 10095, 10098* (BING).

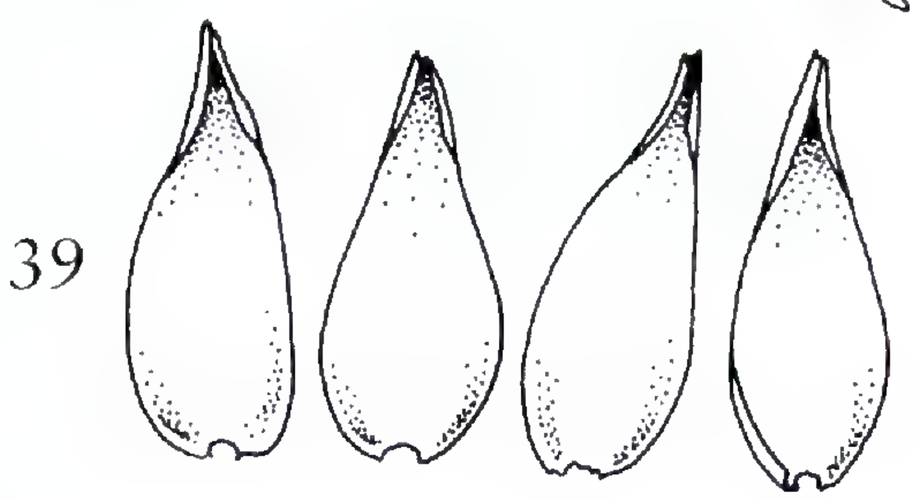
Sphagnum talbotianum Andrus, sp. nov. (**Figs. 34–39**). TYPE: U.S.A. ALASKA: Bethel Co.: Bethel, 0.9 mi down BIA Rd. by turnoff for Chief Eddie Hoffman Hwy, just W of Larson Subdivision, medium fen, *Andrus 9526* (HOLOTYPE: DUKE; ISOTYPES: BING, NY, TRH). *Sphagnum* sect. *Acutifolia.*

Planta rubri-pigmentifera, capitulo in apice complanato, subdenso. Cortex caulinus eporosus. Folia caulina









FIGS. 35–40. *Sphagnum talbotianum*. **35.** Habit. **36.** Two branches. **37.** Stem leaves. **38.** Stem leaf hyaline cells. **39.** Branch leaves. **40.** Branch leaf, convex surface. A = 2 mm, 35; B = 2 mm, 36; C = 0.5 mm, 37, 39; D = 30 µm, 38, 40.

lingulato-triangularia vel lingulata, in apice plusminusve obtusa, 0.8–1.05 mm longa, 0–0.55 mm lata, limbo ad basem valde distincto, cellulis hyalinis rhombiformibus, 0–1 septatis,et fibrillis et poris carentibus. Folia ramulina stricta et ovato-lanceolata, 1.0–1.2 mm longa, 0.3–0.35 mm lata, quinqueordinata, laxe patentia; cellulae in superficie convexa poris quoad amplitudinem mediocribus, in apice 4–6 µm usque in base minoribus quam 20 µm, in superficie concava eporosae praeter interdum in partibus lateralibus infernis poris magnis rotundatis praeditae. Status sexualis ignotis.

Plants pink-colored; capitulum flat-topped and moderately dense. **Stem** red-tinged, cortex eporose. **Stem leaves** triangular-lingulate to lingulate with a more or less obtuse apex,

0.8–1.05 mm. long × 0.5–0.55 mm. wide; border strongly developed at the base; hyaline cells rhomboidal and 0–1 septate, efibrillose and eporose. **Branches** with leaves 5-ranked and loosely spreading. **Branch leaves** small, 1,0–1.2 mm. long × 0.3–0.35 mm. wide; convex surface with moderate- sized pores, grading from 4–6 µm near apex to more than 20 µm at base, concave surface eporose except for occasional large round pores in proximal side regions. **Sexual condition** unknown.

Distribution.—Western Alaska. Currently known from Bethel, King Salmon, and Koyukuk National Wildlife Refuge.

Identification.—As far as other red *Acutifolia* within its general range, *S. talbotianum* is most similar to *S. rubellum* Wils. and *S. warnstorfii*. *Sphagnum rubellum* has a lingulate stem leaf with at least some hyaline cells 2-septate whereas *S. talbotianum* has stem leaves that are often triangular-lingulate and with hyaline cells that are 0–1 septate. The branch leaves on *S. rubellum* are also often subsecund while those of *S. talbotianum* are straight. *Sphagnum warnstorfii* looks quite similar macroscopically but has much smaller ringed pores on the convex surface of the branch leaf tips.

Ecology.—Collections to date indicate this to be a quite widespread tundra species of minerotrophic peatlands. It typically forms low dense hummocks. Compared to *S.rubellum* Wils. and *S. warnstorfii* Russow, the other abundant red quinquefarious *Acutifolia* with which its range overlaps, *S. talbotianum* occurs in richer sites than *S. rubellum* and poorer sites than *S. warnstorfii*.. Common associated *Sphagna* include *S. lenense* Pohle. *S. squarrosum Crome, S. teres (Schimp.) Aongs., S. brevifolium (Braithw.) Warnst., S. arcticum* Flatberg & Frisvoll, *S. subsecundum* Nees, *S. perfoliatum* Savicz-Lubitskaya, *S. obtusum* Warnst., *S. alaskense* Andrus & Janssens, and *S. steerei* Andrus.

Etymology.—*Sphagnum talbotianum* honors Stephen Talbot, who has collected more *Sphagnum* in more remote areas of Alaska than any other botanist. He deserves more credit than anyone else for our current knowledge of the distribution of *Sphagnum* in that state.

Additional collections examined: **ALASKA:** Koyukuk National Wildlife Refuge, 21 Aug 1989, *Talbot & Talbot 8-8-16* (BING); Yukon Delta National Wildlife Refuge, Kuskokwim River Delta, (mixed with *S. lenense*) 15 Aug 2001, *Andrus 9465* (BING, DUKE, NY); King Salmon, near village, 5 Jul 2001, *Andrus 9522* (BING, DUKE, NY); King Salmon area, ca. 39 km SW on maritime tundra, 6 Aug 2001, *Andrus 9354* (BING, DUKE, NY).

REFERENCE

FLATBERG, K.I. Studies in *Sphagnum subfulvum* Sjoers, and related morphotypes. Lindbergia 11:38–54.

REVIEW OF *CRATAEGUS* SERIES *PULCHERRIMAE* (ROSACEAE)

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ABSTRACT

Crataegus series *Pulcherrimae* (Rosaceae) is reviewed, Beadle's group *Sargentianae* being incorporated. Ten species, *C. sargentii*, *C. gilva*, *C. mendosa*, *C. pulcherrima*, *C. pinetorum*, *C. venusta*, *C. opima*, *C. tecta*, *C. pallens*, and *C. eximia* are recognized. In addition, a possible eleventh species, *C. ?robur*, is suggested but the evidence is not yet final on this. All species are lectotypified here except *C. pinetorum*, which is neotypified. Epitypes are proposed for two species, *C. opima* and *C. venusta*. Synonyms are also typified. Each species is keyed out and is represented by the most detailed description to date. Detailed line illustrations and county level range maps, in both cases generally the first for each species, are provided. Repesentative specimens are cited.

KEY WORDS: *Crataegus*, series *Pulcherrimae*, group *Sargentianae*, typification

RESUMEN

Se revisa *Crataegus* serie *Pulcherrimae* (Rosaceae), se incorpora el grupo *Sargentianae* de Beadle. Se reconocen diez especies, *C. sargentii*, *C. gilva*, *C. mendosa*, *C. pulcherrima*, *C. pinetorum*, *C. venusta*, *C. opima*, *C. tecta*, *C. pallens*, y *C. eximia*. Además, se sugiere una posible undécima especie, *C. ?robur*, pero no hay pruebas finales aún. Se lectotipifican todas las especies excepto *C. pinetorum*, que es neotipificada. Se proponen epitipos para dos especies, *C. opima* y *C. venusta*. También se tipifican los sinónimos. Se aporta una clave para todas las especies y se ofrece la descripción más detallada hasta la fecha. Se realizan ilustraciones detalladas y se aportan mapas de distribución a nivel de condado, de ambos generalmente es el primero para cada especie. Se citan especimenes representativos.

The group *Pulcherrimae*, without formal rank or description, was first used by Beadle (1902) in the preparatory paper for his treatment in Small's (1903) Flora of the southeastern United States, edition 2. In the two publications Beadle's treatments are identical and it is notable that all but the Type species, *C. pulcherrima*, were described by Beadle. Beadle's *Pulcherrimae*, which he treated as a group of nine species, was noticed by Sargent (1905) and was used in Palmer's (1925) nomenclator but it was not formally recognized until Robertson (1974) carefully validated the name. Beadle (1902) also recognized another group, *Sargentianae*, of 15 species, all described by him, that in my opinion cannot meaningfully be distinguished from *Pulcherrimae* and it is therefore here included with the latter group such that it now has 24 described species.

Later, Tidestrom, in Small's Manual of the Southeastern Flora (1933), dispensed with all the species of *Pulcherrimae* and *Sargentianae*, and henceforth floras of the region usually followed this example. A few, however, like Kurz and Godfrey (1962) did recognize the existence of the series and thus, a handful of its species continued to appear sporadically.

This paper, based on the examination of 374 herbarium sheets from 25 herbaria and numerous field trips to the relevant region, reviews series *Pulcherrimae* as a whole for

the first time since Beadle inaugurated the groups *Pulcherrimae* and *Sargentianae* in 1902. Like other members of this series of papers, this one is a precursor to the author's treatment in Flora of North America, vol. 9, due to be published next year. As such, it is not intended to make a deep analysis of serial boundaries or relationships but rather has the principal aim of assessing the individual species to be recognized. Nevertheless, a few obviously necessary adjustments to serial boundaries are provided in papers for this series. Accordingly, I am characterizing series *Pulcherrimae* as being almost completely glabrous at maturity, having possession of 20 stamens, red or yellow fruit and a somewhat elevated fruiting calyx. Though this diagnosis now includes Beadle's group *Sargentianae* the expanded series does not appear to meaningfully widen the original diagnosis for ser. *Pulcherrimae*. The relationships of ser. *Pulcherrimae* are clearly to ser. *Intricatae*. Indeed, ser. *Intricatae*, a mainly 10-stamen group with a number of very hairy species, is not in other respects very different from ser. *Pulcherrimae* and the two may eventually be fused, a procedure which is, however, not appropriate to this paper. Series *Pulcherrimae*, whether considered in its narrow sense or in the extended sense (including *Sargentianae*), is restricted to the southeastern United States except for some overflow into southeastern Texas.

The approach used for this work, after the series boundaries had been settled on, was to study the maximum number of specimens possible over an approximate 15-year time frame. Accordingly, loans were requested from over 40 herbaria in the southeast plus several national herbaria with significant *Crataegus* collections. Only 24 institutions, however, were able to produce specimens of this series. Therefore the first author, assisted often by O'Kennon, made numerous field trips to the region to search for further specimens of ser. *Pulcherrimae* as well as other *Crataegus* species. The results of this fieldwork proved very helpful and review of the appendix of cited specimens shows that UWO now has more *Pulcherrimae* exemplars than the totality of specimens received on loan from all other herbaria. The specimens received on loan plus the UWO collections were then grouped into the more distinctive and repeatedly encountered morphotypes with few if any intermediates between them. These were then described in detail, where possible, by matching with type material, which is well represented for this series. The names used were typified, a key to taxa recognized made and then line illustrations and distribution maps were produced, nearly always for the first time, for nearly all of the species recognized. The taxonomic conclusions are those of the first author while the county distribution maps were produced by K.A. Dvorsky, working from the UWO database of specimens.

Difficulties working with series *Pulcherrimae* stem from certain problems in working with Beadle's text, particularly his imprecise description of leaf shapes as exemplified by his use of the phrase "leaf margins lobed and incised, leaves ovate" (or very similar) for nearly all taxa, although inspection nevertheless demonstrates some clear and striking differences in leaf shape. Indeed, this shape characteristic proves to be the main taxonomic discriminator between species as recognized in this paper, rather than Beadle's emphasis on fruit colour (red and yellow being usual in the series), fresh anther color, or flower size which do not seem to correlate sufficiently well with other characters to be generally useful. Furthermore, most collectors, including Beadle, have not recorded color characters with their label data, making them especially difficult to use with herbarium material. UWO collections are among the few that routinely record these characters. Another problem is that series *Pulcherrimae* does not seem to be particularly common

except in sporadic favored locations. It is difficult to tell how much more abundant members of the series were in Beadle's time, but, although a number of label annotations indicate very high abundances, i.e., 'thousands' (very unusual today), the main collectors of this period, Beadle himself and Harbison, Biltmore's collector, collected few specimens that survive other than the early collections associated with the protologues. Thus it is essentially impossible to infer the level of change in frequency over the last 100 years or so.

Apomixis, polyploidy and perhaps hybridization (Phipps, 2005) contribute to taxonomic difficulty in *Crataegus* but so far no one has studied breeding systems in ser. *Pulcherrimae*, and only two chromosome counts or ploidy level estimates exist. Talent and Dickinson (2005) report a triploid ploidy level from an unidentified species and Longley (1924) a triploid count from *C. pinetorum*. One cannot generalize from so little information. Hybridization is first suggested by morphological intermediacy and as such there is no definite suggestion of it occurring in ser. *Pulcherrimae*.

This is, therefore, a somewhat provisional treatment of ser. *Pulcherrimae* and because of the problems noted it is necessarily grounded in the work of Beadle, the only previous worker who has paid serious attention to the group. In attempting to place all of Beadle's 1902 and 1903 names in his groups *Pulcherrimae* and *Sargentianae* into the synonymy for this paper I have occasionally come up with only a possible, rather than a definite match. This itself speaks to difficulties of species level synonymy in series *Pulcherrimae*. Further, whereas most specimens can be more or less straightforwardly accomodated in the taxa that I recognize here, there is a general residue of about 3% (see Appendix of Cited Specimens) of specimens of adequate quality where this is less straightforward. Because of this somewhat provisional state of the taxonomy, we also provide a map to the collective distribution of the series (Fig. 1). Thus, this will not be the last word on ser. *Pulcherrimae* and even more collecting as well as some combination of morphometric work, biosystematic investigation and molecular studies will be needed to stabilize the understanding of all its species. It is therefore to be hoped that a competent systematist, preferably conveniently based in the southeast, will be encouraged by the platform presented here to carry out such work.

This paper is a continuation of the first author's studies of *Crataegus* in the southeastern United States, examples of which are Phipps (1988) and Phipps and Dvorsky (2006). Because these papers were originally intended to provide the detailed backup for the first author's treatment of *Crataegus* in the southestern United States for Cronquist's now defunct flora of that area, our meaning of "southeastern United States" here is identical to Cronquist's, ie. Louisiana and Arkansas are the western limits for that flora. Texan records are, however, added but only because a few species are of sporadic occurence in the extreme southeast of that state.

The text continues with the formal taxonomic presentation.

TAXONOMY

Series **Pulcherrimae** Beadle ex K.R. Robertson, J. Arnold Arbor. 55:628.1974. TYPE species: *Crataegus pulcherrima* Ashe, *Pulcherrimae* Beadle, group without rank or description, Biltmore Bot. Stud. 1:66. 1902; *Pulcherrimae* Beadle ex Sargent, in clavem, Man. Trees North Amer. 1:400. 1905; group *Pulcherrimae* E.J. Palmer, in clavem, J. Arnold Arbor. 5:78. 1925.

Note.—Robertson attributed sectional rank for this group by Palmer (1925), but I argue that Palmer was not formally using the rank section there (Phipps, Harvard Pap. Bot., submitted).

Sargentianae Beadle, group without rank or description, Biltmore Bot. Stud. 1:59.1902.

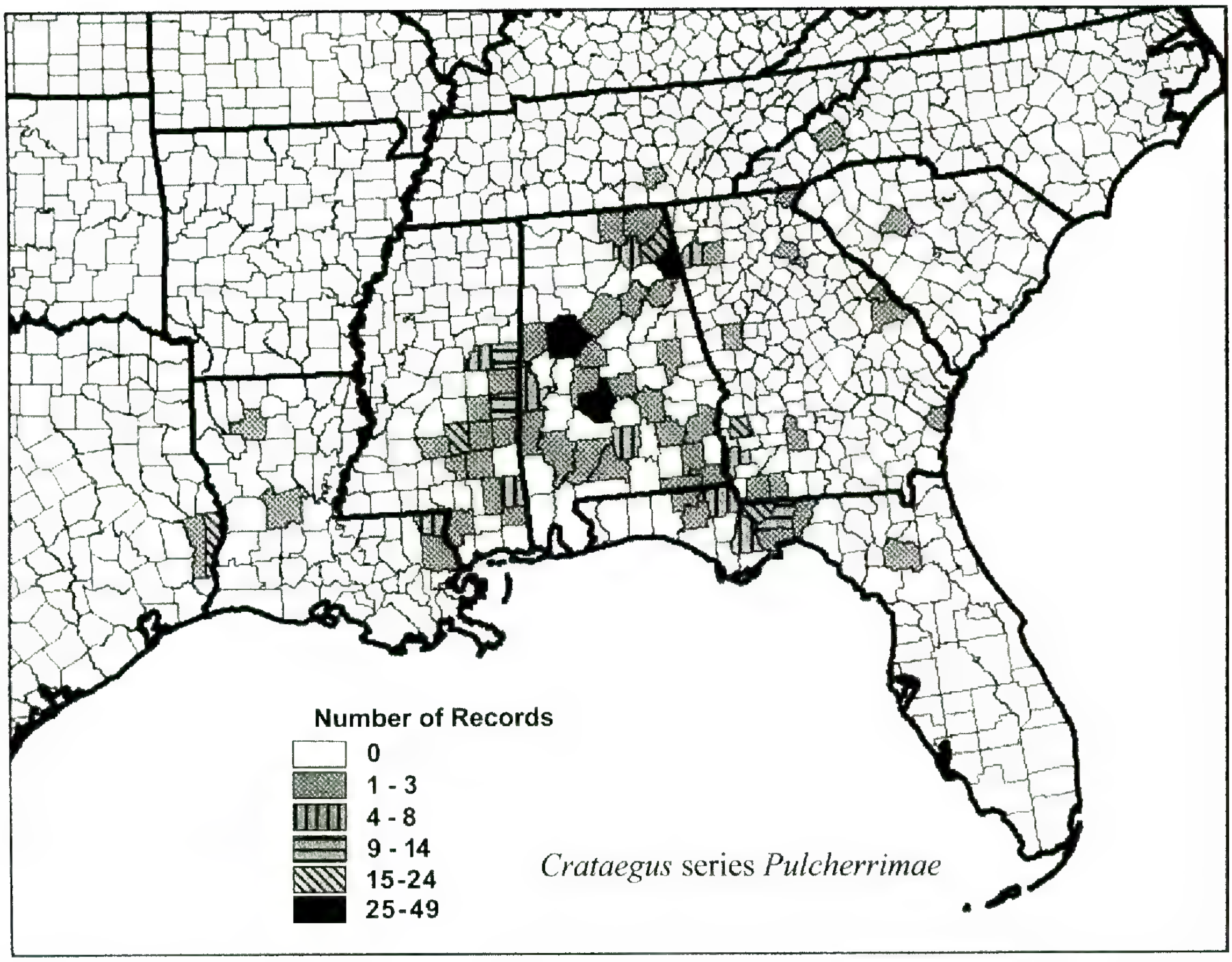


Fig. 1. County level distribution map of *Crataegus* series *Pulcherrimae* from collated records.

Shrubs or small trees; 1-year old twigs shiny golden-tan to shiny deep reddish-brown; 2-yr old twigs deep gray; thorns mostly 2–3 cm long, fine, very dark at 2 yr. Leaves deciduous, long-petiolate; petiole glabrous, bearing a few to several, sometimes stipitate, glands; blades 4–7 cm long, ovate to ovate-rhombic or narrow-ovate in general outline, unlobed or more frequently with 4–6 shallow lobes per side, sometimes all of the lobes or only the upper, obscure, lobe tips blunt to acute; venation craspedodromous, 4–11 veins per side; ± glabrous. Inflorescences 5–10 flowered slightly domed panicles; branches glabrous, bearing often plentiful, caducous, membranous, linear, gland-margined bracteoles. Flowers 14–18 mm diam.; hypanthium externally glabrous; calyx-lobes narrow-triangular, glandular-serrate to nearly entire; petals ± circular, white; stamens 20, anthers usually pink to purple, sometimes cream (e.g. *C. venusta)*; styles 2–5. Fruit 5(Beadle)–13 mm thick, pyriform to ± orbicular, glabrous, yellow, orange, ruddy, red, red-purple or green; calyx lobes usually reflexed on a short collar; pyrenes 2–5. Mature bark deeply corrugated at least in some.

Series *Pulcherrimae* occurs from the Gulf Coast of eastern Texas to northern Florida. Its species are collectively fairly common over much of Mississippi and Alabama as well as the western part of Georgia. There are also sporadic records east to South Carolina, one record in southern Tennessee and one locality for North Carolina in Buncombe County. Ten definite and one possible species are recognized here.

For the whole series, flowering is in April through much of Mississippi, Alabama and Georgia but, in panhandle Florida, it may start late March and in North Carolina or Tennessee in May. According to the season, typical timing may be retarded or speeded up by cooler or warmer weather than normal. The south-north progression is typical for spring flowering plants in the region (e.g. Reader et al. 1974). Fruit is ripe anywhere from late August to early October and its retention past the early stages depends on the mesicity of the site and seasonal weather until full ripeness makes the fruit attractive to frugivores.

Related species of *Crataegus* usually show little or no habitat variation in their physical habitat such that niche differentiation, if it exists, must be based on other characteristics. Series *Pulcherrimae* is normative for the genus in this respect as far as present observation indicates and the plants are woodland edge or woodland species of mesic localities, if the latter, usually under oak or oak-mixed canopy but not in the denser shade. Soil type preference for the mesomorphic members of the genus is also not normally pronounced with the exception of avoiding coarse-grained or more acid soils. Species of ser. *Pulcherrimae* are mainly recorded on the finer-grained soils. A reviewer makes the suggestion that the distribution of *C. venusta*, however, may be restricted to blackland soils, a soil type that certainly harbors hawthorns, but this cannot be confirmed from data available to me. Three of the mechanisms for niche differentiation in *Crataegus* are: differential anthesis timing, different pollinator preference and fruit differentiation (color, time of ripening, size, perhaps taste) and several of these differences do occur with ser. *Pulcherrimae* but have not been investigated further. Differences in anthesis time in sympatric *Crataegus* may be very large, up to six weeks, but usually correlate to taxononomic distance (for more on this see Phipps 1995, on hybridization), so they likely do not initiate niche differentiation. In the case of ser. *Pulcherrimae* different taxa that occur at the same site do sometimes have slightly different, but overlapping, anthesis time but there is no consistent recording of this. There is also an untested suggestion that differences in fresh anther color (basically, anthocyanic or not) may affect pollinator faithfulness, thus beginning niche differentiation. In this respect it is interesting that such color differences quite often appear in very closely related taxa, though they are not particularly frequent within single species. There is a huge field of study here awaiting attention by an enterprising biologist but it clearly needs preceeding by a plausible taxonomy against which it can be tested.

The deeply corrugated bark of several species, found in few other series, glabrous or nearly glabrous plant parts (except in one aberrant specimen), about 20 stamens, rather glandular-bracteolate inflorescences, usually spreading, somewhat elevated calyx-lobes in fruit, and sometimes large numbers of lateral veins in the leaf make this series distinctive. It is thus a quite easily recognized series, except for its differentiation from ser. *Intricatae*, which latter normally possesses 10, not 20, stamens as in ser. *Pulcherrimae* and has some very hairy species. As in series *Intricatae*, yellowish-fruited forms are at least as numerous as red-fruited ones.

Notes on terminology:

1. This paper uses the term 'leaf incision index,' abbreviated to LII, for the relative depth of sinuses. This is measured by joining the lobe tips and projecting a line from there through the deepest part of the sinus, parallel to the adjacent veins, to the mid-vein. A one hundred percent value indicates cut through to the mid-vein, 50% cut half-way, cut 25% of the way to the mid-vein.
2. "Leaf' always refers to short-shoot leaves unless indicated otherwise.

KEY TO SERIES *PULCHERRIMAE*

A. Inflorescence branches glaprous _____ [ser'es **Pulcherrimae,** sens. str.].

1. Well-developed short-shoot leaf blades fairly narrow, 1.5–2 × as long as broad.
   2. Well-developed short-shoot leaf-blades narrow-elliptic to narrow-ovate in general outline; lobes absent or very shallow, perhaps some notches with LII 5% or even 10%, but if so not regularly occurring in all or most leaves; lateral veins 6–10/side.
      3. Leaf blades broad-elliptic to narrow-ovate in general shape; apices subacute to blunt; margins with crenate or crenate-serrate teeth; fruit red _____ **3. C. mendosa**
      3. Leaf blades narrow ovate to lanceolate in general shape; apices acute to acuminate; marginal teeth sharply acute; fruit yellowish _____ **2. C. gilva**
   2. Well-developed short-shoot leaf blades broad-elliptic or broad-oblong to narrow-ovate in general outline; regularly and distinctly lobed; max. LII 10–40%; main lateral veins 4 6/ side.
      4. Lobes 2–3 per side, blunt, max. LII <15% _____ **4. C. pulcherrima**
      4. Lobes 2–5 per side, blunt or acute, max. LII <15–25% or more.
         5. Leaf blades narrowly elliptic to very narrow-ovate in general outline; 1–2 (–3) shallow, acute lobes per side, max. LII usually <15% _____ **5. C. pinetorum**
         5. Leaf blades narrowly ovate in general outline; 4–5 deep, acute to subacute, usually narrow-cuspidate lobes per side, max. LII often 25% or more _____ **9. C. incilis**
1. Well-developed short-shoot leaf blades broader in proportion, generally < 1.5× as long as wide.
   6. Many leaves of a distinctive type, ± trullate-ovate in general shape, the terminal half ± straight-sided across lobe-tips; 4–6 cm long; lobes 1–3/side, sharp, but very small to small (max. LII 2–10%(–15%)); 5–7 lateral veins/side; anthers pink; fruit yellowish _____ **1. C. sargentii**
   6. Leaves of quite different construction; if with few, short, very acute lobes then blades more ovate or oblong in form and the terminal half not ± straight sided across the lobe tips; length various; lobes nearly always much more pronounced, at least at maturity; venation various; anthers ivory to cream or pink to purple; fruit yellowish or reddish.
      7. Leaf blades with well-marked lobes, max. LII usually 15–25%, occasionally more.
         8. Blades usually smaller, 3–5(–8) cm long, ovate to broad-ovate in general shape; lobes angular or not; anthers and fruit various colors.
            9. Majority of leaves broad-ovate in general shape with 4–5 lateral veins per side and 3–4 lobes; lobes short or longer (max. LII 10–40%).
               10. Lobes ± blunt, generally fairly short (m3max. LII 20–40%) _____ **8. C. tecta**
            9. Majority of leaves ovate in general shape with 5–8 lateral veins per side and 4–6(–7) lobes; lobes fairly short, obtuse to acute (max. LII 10–40%) _____ **7a. C.** cf. **opima**
         8. Blades large, 5–8 cm long, rhombovate in general shape; lobes very angular; anthers cream; fruit red _____ **10. C. eximia**
      7. Leaf blades with shallow lobes, max LII 5 10%.
         11. Lobes quite sharp.
            12. Leaf blades broad-oblong to oblong-ovate; lobes and teeth acuminate during development, sometimes reflexed _____ **6. C. venusta**
            12. Leaf blades narrow ovate to ovate-oblong; tips of lobes and marginal teeth less pronounced.
               13. Leaf blades ovate-oblong in general shape; angle at leaf-tip broad, ca. 90° _____ **6. C. venusta, 'pallens'** form
               13. Leaf blades narrow-ovate in general shape; angle at leaf-tip sharp, 60° or less _____ **2. C. gilva**
         11. Lobes blunt to subacute.
            14. Leaf blades generally large at maturity, mostly 5–8 cm long; lateral veins 5–7 per side; blades nearly unlobed to shallowly lobed; bases cuneate _____ **3a. C.** cf. **C. mendosa**
            14. Leaf blades small to medium-sized, rarely many > 5 cm long; lateral veins 4–7 per side; blades regularly lobed, but sometimes shallowly; bases cuneate to rounded.

15. Leaf blades cuneate at the base, most blades approximately 1.5:1 _____ **4. C. pulcherrima**

15. Leaf blades broad-cuneate to rounded at the base, blades <1.5:1 _____ **7. C. opima**

B. Inflorescence branches pubescent _____ **C. craytonii** ser. **Intricatae]**

1. Crataegus sargentii Beadle, Bot. Gaz. 28:407. 1899. (**Fig. 2.**) TYPE: U.S.A. ALABAMA. De Kalb Co.: Valley Head, 20 Sep 1899, *C.D. Beadle 1289* (LECTOTYPE selected here: US 969465; ISOLECTOTYPE: US 969466).

?=*Crataegus assimilis* Beadle, Biltmore Bot. Stud., 1:68. 1902. TYPE: U.S.A. FLORIDA. Jackson Co.:Chattahoochee, 8 Apr 1901, *T.G. Harbison H4096* (LECTOTYPE selected here: US 969401).

Shrubs or small trees 3–5 m tall; extending twigs glabrous, reddish; at 1 yr. shiny deep reddish-brown, 2 yrs grayish-red, older gray; thorns 2–5 cm long, few to numerous, slender, straight to slightly recurved, black at 2 yrs. Leaves: petioles 25–40% length of blade, slender, glabrous, with a few sessile glands; blades 4–6(–7) cm long, ovate-trullate in general outline; tip acute to acuminate, base rounded to broad cuneate; sides barely or shallowly 1–3 lobed; lobes acute, max. LII usually 0–10%; upper third of leaf often unlobed; margins finely and sharply serrate with numerous very small teeth usually ≤ 1 mm long; venation craspedodromous, with 5–7 main lateral veins/side; leaves glabrous except for scattered hairs on the veins above when young. Inflorescences 4–10(–11) flowered; branches glabrous, bearing numerous, caducous, linear, often somewhat curved, membranous to subherbaceous (green), gland-margined bracteoles; anthesis late March (Gulf Coast) to mid-April (Alabama canyon lands). Flowers 15–18 mm diam.; hypanthium externally glabrous; calyx-lobes 3 mm long, narrow-triangular, flaring to a broad base, tip somewhat obtuse, margins entire to glandular-denticulate, abaxially glabrous; petals ± circular, white; stamens 20, anthers pale pink to pale purple; styles 3–4. Fruit 8–10(–12) mm diam., subglobose, yellow or flushed pink (occ. reddish); calyx lobes reflexed, on an elevated collar; nutlets 3–4, dorsally grooved, sides plane.

Common name.—Sargent's hawthorn

Habitat and Distribution.—Our records are mainly from Alabama, extending west to central Mississippi, south to panhandle Florida and eastwards with scattered records from Georgia (Fig. 3). It is a locally common species of woodland edges, cut-over woodland and other open woodland.

Comment.—*Crataegus sargentii* was the first species to be described in the series and this account appears to be the first to characterize it fully. It is most similar to *C. gilva* but that species has narrower leaves and smaller fruit. Occasional more deeply lobed forms (LII ca. 15%) may resemble other species to some extent, but they will normally retain the characteristic overall leaf-form of the species.

2. Crataegus gilva Beadle. Biltmore Bot. Stud. 1:60. 1902. (**Fig. 4**). TYPE: U.S.A. ALABAMA. Marshall Co.: rocky woods, Apr 1901, *T.G. Harbison 4374* (LECTOTYPE selected here: A).

Shrubs or small trees 2–5 m tall; extending shoots glabrous, reddish when young; at 1 yr deep reddish-brown, older dark dull gray; thorns fine, 2–4 cm long, straight or slightly recurved, dull purplish-brown at 2 yr. Leaves: petioles slender, ca. 20–30% length of blade, adaxially grooved, ± glandular; blades 3.5–4.5 cm long, broad-lanceolate to narrow-elliptic or very narrow ovate to narrow ovate or narrow ovate-rhombic; tip acute to acuminate and with 0–3 acute lobes per side these with max. LII usually ≤ 15%; margins sharply fine-serrate or occasionally with quite large teeth; venation craspedodromous, lateral veins ca. 5–7(–9) per side on average or larger short-shoot leaves; glabrous above and be-

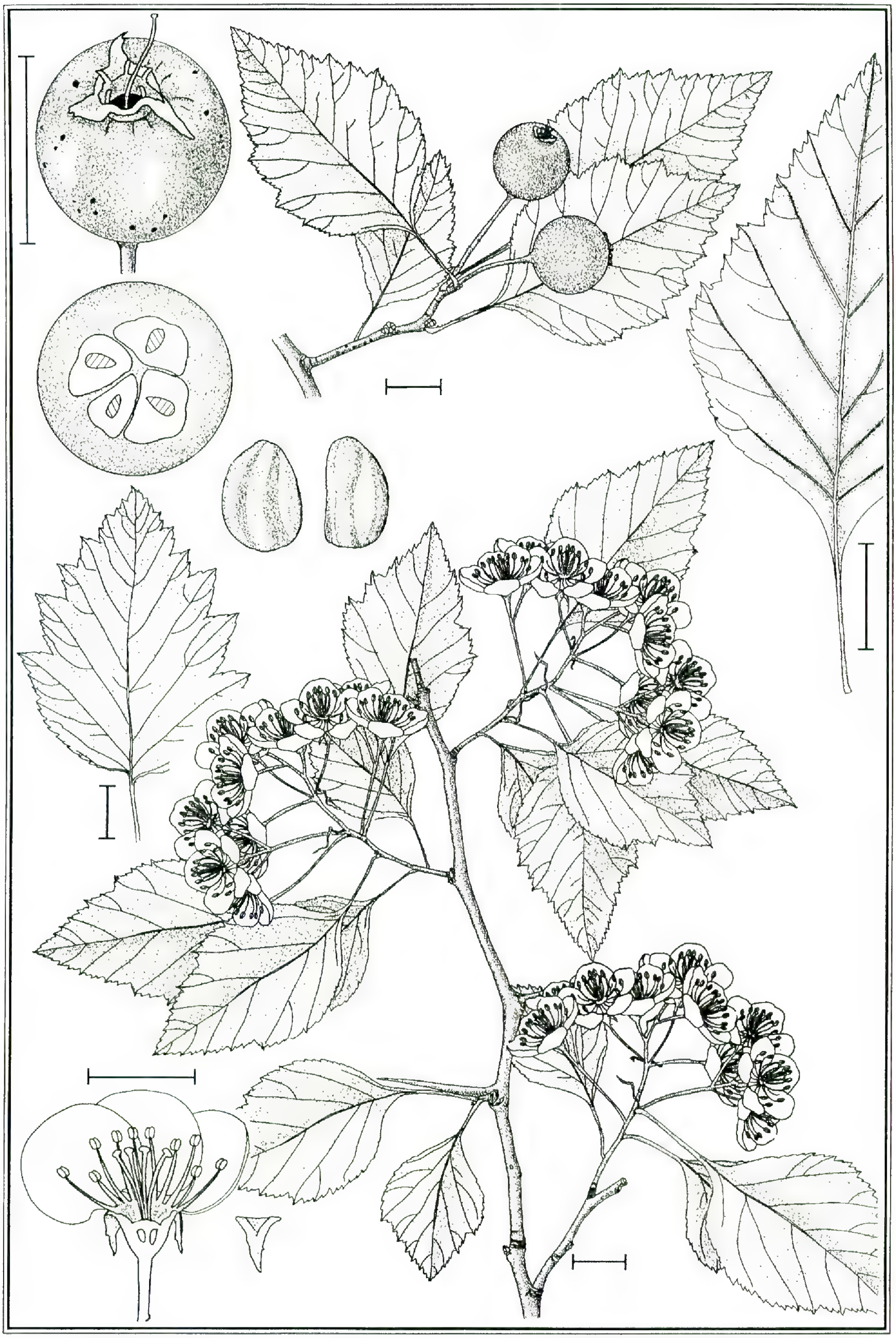


Fig. 2. Line drawing of *Crataegus sargentii* from flowering specimen *Ulf Hansen PF037* (UWO) and fruiting specimen *Lance 2171* (UWO); single leaf at left from extension shoot. Scale bars = 1 cm. S. Laurie-Bourque del.

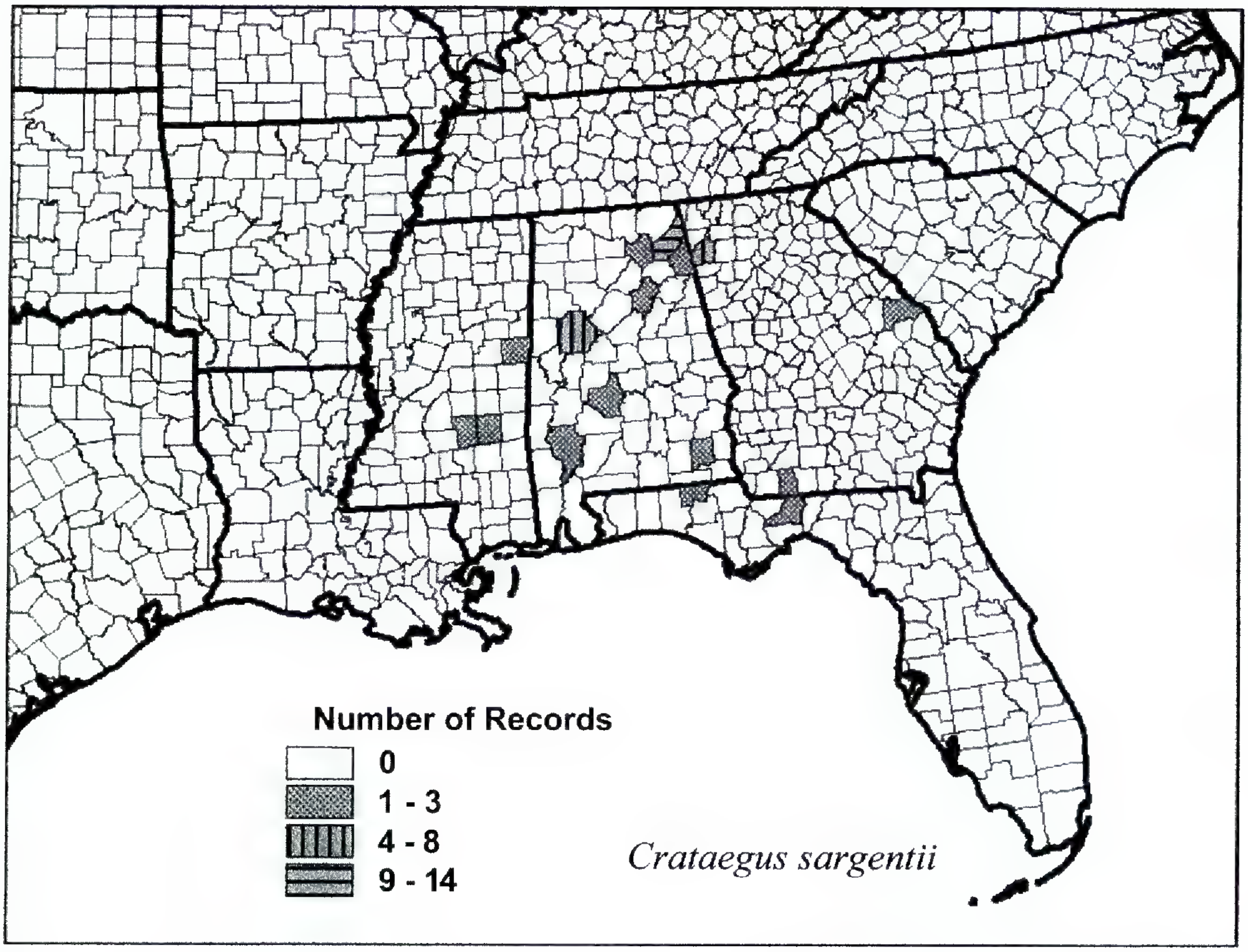


FIG. 3. County level distribution map of *Crataegus sargentii* from collated records.

low except for some hairs on the veins above especially when young. Inflorescences usually 3–7 flowered; branches glabrous, densely beset with caducous, narrow-oblong to very narrow obovate, membranous to subherbaceous, densely gland-margined bracteoles. Flowers (13–)18–20 mm diam.; hypanthium externally glabrous; calyx-lobes 6–7 mm long, narrow triangular, margins glandular-serrate; petals ± circular, white; stamens 20, anthers pale pink; styles 3–4. Fruit ca. 5–8 mm wide at maturity, ± orbicular, greenish yellow to yellow; sepals ± reflexed; nutlets 3–4.

Habitat and Distribution.—*Crataegus gilva* occurs from Mississippi to Georgia and northern Florida (Fig. 5), in woodland edges and gaps, clear-cuts and pine-oak woodland.

Comment.—*Crataegus gilva* leaves are rather like a sharp-tipped *C. mendosa* and and somewhat resemble a much less clearly lobed *C. pinetorum*. The leaves are also usually somewhat like a proportionately narrower *C. sargentii* and in the flowering Type they are narrow-elliptic, acuminate at the tip, cuneate at the base, virtually devoid of lobes and have particularly large marginal teeth, this being the most extreme specimen of the species seen. The suspicion that *C. gilva* may represent an extreme form of *C. sargentii* is heightened by the almost complete lack of known fruiting specimens of the species, the fruiting co-type excepted (*Harbison 4374/2*), which specimen, therefore, does suggest the possibility that the leaves often widen after anthesis.

3. Crataegus mendosa Beadle, Biltmore Bot. Stud. 1:65. 1902. (**Fig. 6**). TYPE: U.S.A. ALABAMA. Marshall Co.: near Albertville, 18 Oct 1901, *T.G. Harbison 5219* (= *4336/2*) (lectotype selected here: US 969431).

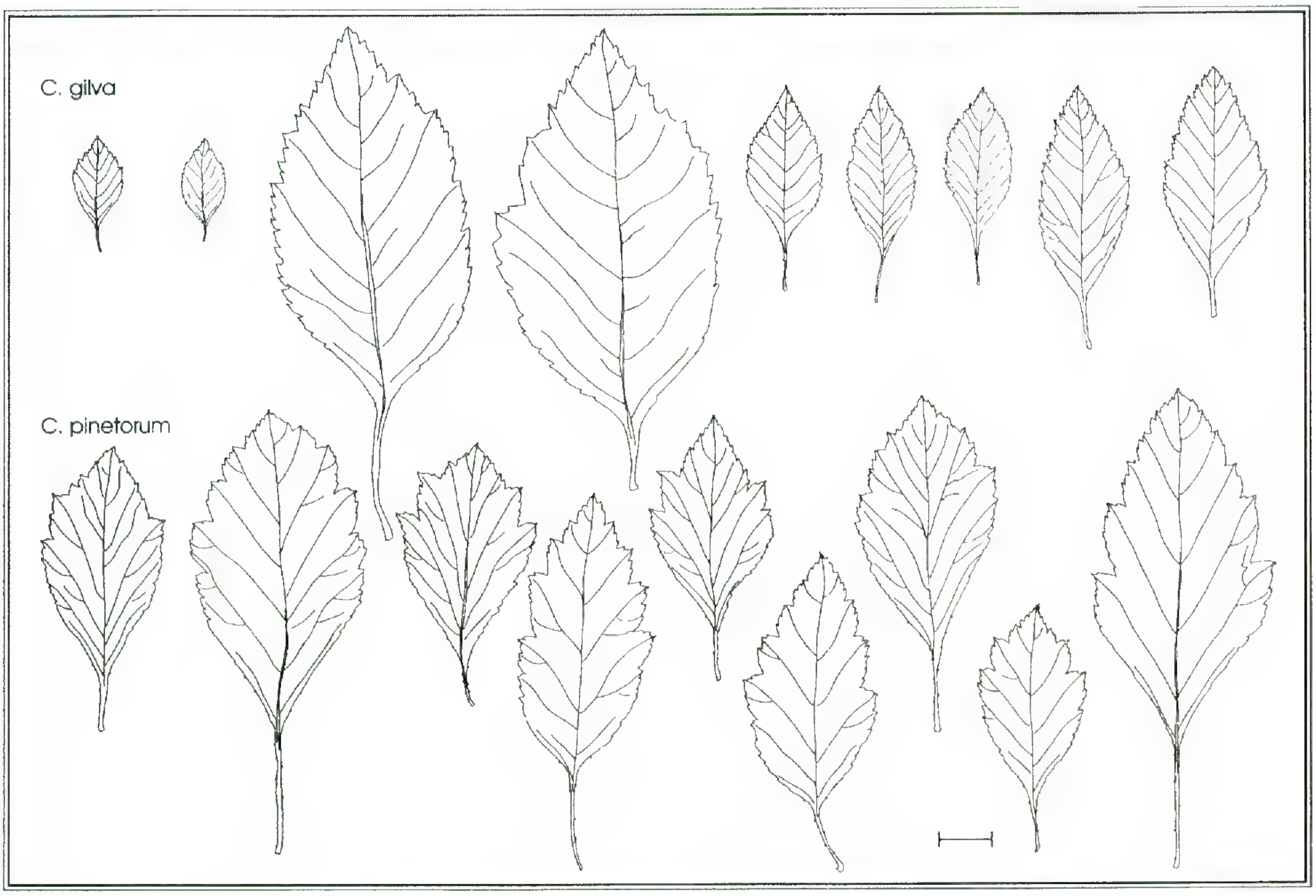


FIG. 4. Line drawing of leaf spectra of *Crataegus gilva* (top row) from *Lance s.n.* (UWO) and *Phipps 7937a* (UWO) and *C. pinetorum* (bottom row) from, left to right, *Lance 2174* (UWO), *Phipps 8173* (UWO) and *Phipps & O'Kennon 8042* (UWO). Scale bars = 1 cm. S. Laurie-Bourque del.

Shrubs or small trees 3–6 m tall; bark of trunk not recorded; 1-yr old twigs shiny reddish or purplish brown, older dark or dull gray; thorns 2–5 cm long, fine, straight or slightly recurved, reddish black at 1 yr, frequent to absent. Leaves: petioles 30–50% length of blades, dorsally furrowed, bearing a few small glands; blades 4–7 cm long, 2–3 cm wide, broad-oblong to elliptic or narrowly ovate; unlobed or with a few obscure lobes; apex subacute to blunt on some larger leaves, cuneate at the base; margins with numerous, small, sharp teeth; lateral veins 8–9 per side (fewer on smaller leaves), venation craspedodromous; glabrous except for a few hairs on the midvein abaxially when young, dark green. Inflorescences 4–7 flowered; branches glabrous, densely beset with caducous, narrow, semi-herbaceous and green to membranous, gland-margined bracteoles. Flowers 14–17 mm wide; hypanthium externally glabrous; calyx lobes triangular, abaxially glabrous, margins glandular-denticulate; petals ± circular, white; stamens 20, anthers pink or pink-purple; styles 3–5. Fruit 8–10 mm diam., ± orbicular to broad ellipsoid, yellow-green with pink or salmon blush, or red (Beadle); calyx lobes reflexed; nutlets 3–5, dorsally furrowed, laterally smooth.

Habitat and Distribution.—Scattered from extreme southeastern Texas to western Georgia and northern Florida with a disjunct record in South Carolina (Fig. 7), *Crataegus mendosa* is a plant of woodland edges, cut-over woodland and brushy places.

Comment.—*Crataegus mendosa* is one of the more distinctive members of the series although it is approached in form by *C. gilva*, which, however, has an acuminate leaf-tip and much sharper lobes (if present) and marginal teeth. The extension shoot leaves of *C. mendosa* are ovate to broad-ovate in outline with 3–4 sub-acute to acute lobes that are usually quite broad and this can confuse if there are only few typical short-shoot leaves present.

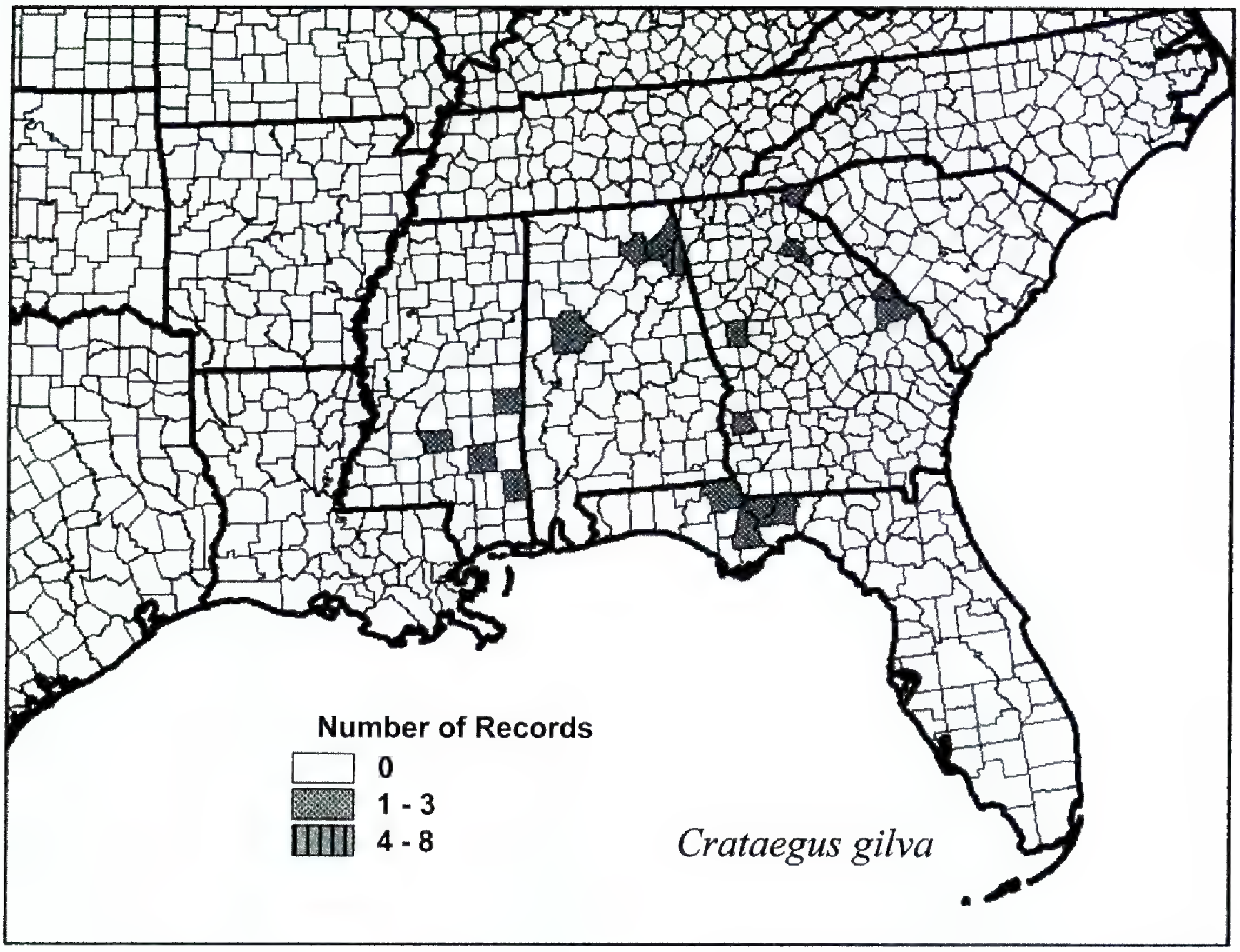


FIG. 5. County level distribution map of *Crataegus gilva* from collated records.

3a. Crataegus cf. **mendosa** Beadle

Shrubs or small trees 3 m tall; mature bark not recorded; extending twigs glabrous, reddish; at 1-yr shiny reddish-brown; older duller dark gray; thorns often on material seen. Leaves: petioles ca. 33% length of blade, glabrous, glandular, adaxially grooved; blades 5–7 cm long, mostly broad-elliptic in general shape; apex subacute, base cuneate to broad cuneate; 0–3 lobed per side, lobes obtuse to subacute, max. LII usually 5–10%; margins serrate; venation craspedodromous, ca. 6 main lateral veins per side; both surfaces glabrous. Inflorescences not recorded. Young infructescences with 2–5 fruit, branches glabrous. Young fruit 7–10 mm diam., subglobose to ± pyriform, green, glabrous; filament bases ca. 20; sepals mainly erose; nutlets ca. 4.

Habitat and Distribution.—Only known from one locality in Alabama, where it is recorded from 'bottoms' from where three fine duplicates at DUKE, GA and NO of *Demaree 50656* (MS: Alabama: Dallas Co., White Oak Creek, P.O. Sardis, 29 June 1964) show a plant intermediate between *C. mendosa*, *C. opima* and *C. pulcherrima* but which cannot be confidently placed with any. More material is needed.

4. Crataegus pulcherrima Ashe, J. Elisha Mitchell Sci. Soc. 16:77. 1900. (**Fig. 8**). TYPE; U.S.A. FLORIDA. Gadsden Co.: River Junction, 10–11 Aug 1895, *G.V. Nash* 2377 (LECOTYPE selected here: DOV 4634; ISOLECTOTYPE: US 250142). I have selected from Ashe's co-types the specimens with better foliage and fewer fruit rather than more fruit and poorer foliage.

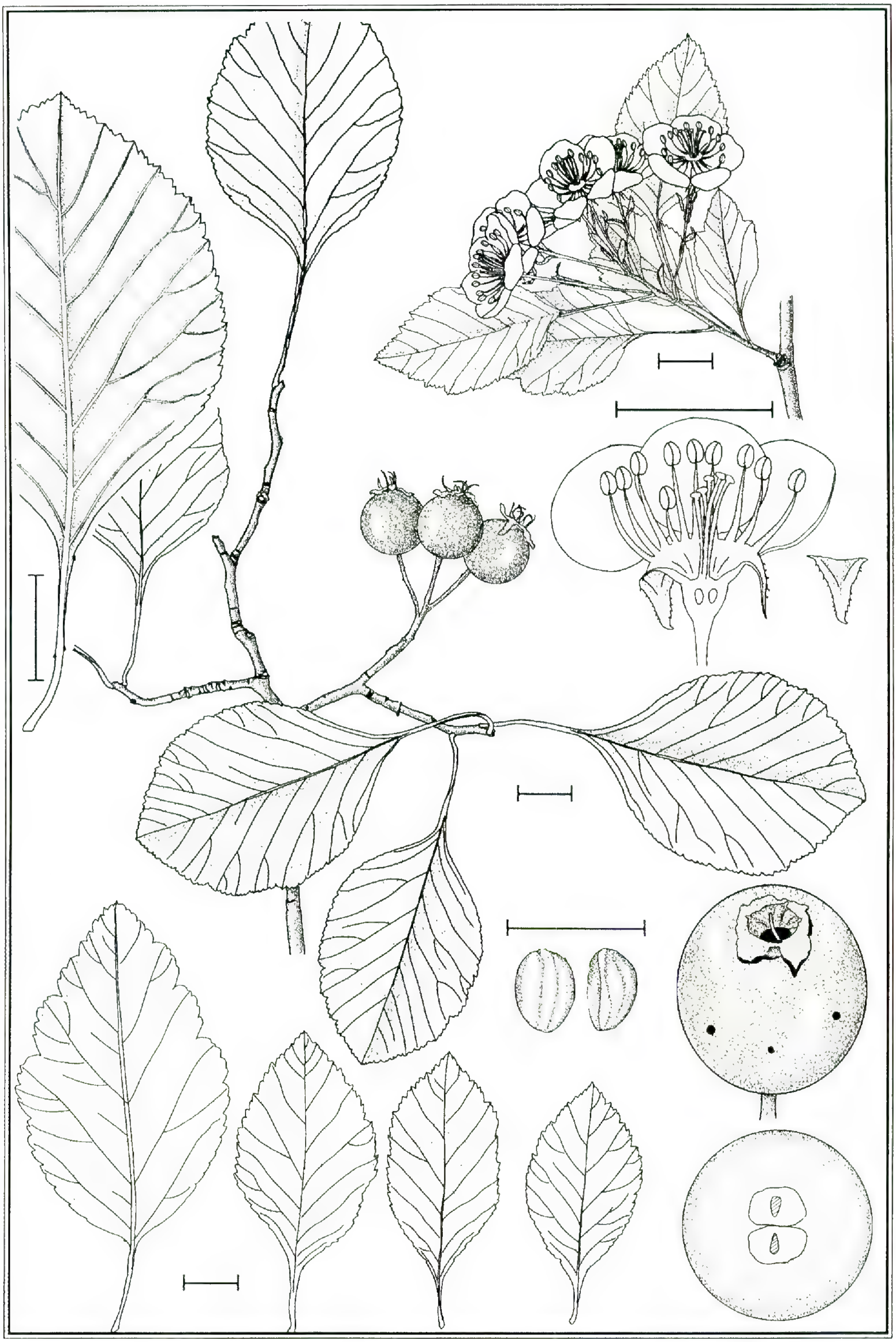


Fig. 6. Line drawing of *Crataegus mendosa* from flowering specimen *Phipps & O'Kennon 7939a* (UWO) and fruiting specimens *Phipps et al. 8088*, *Smith 129* and *Lance 2176* (UWO). Scale bars = 1 cm. S. Laurie-Bourque del.

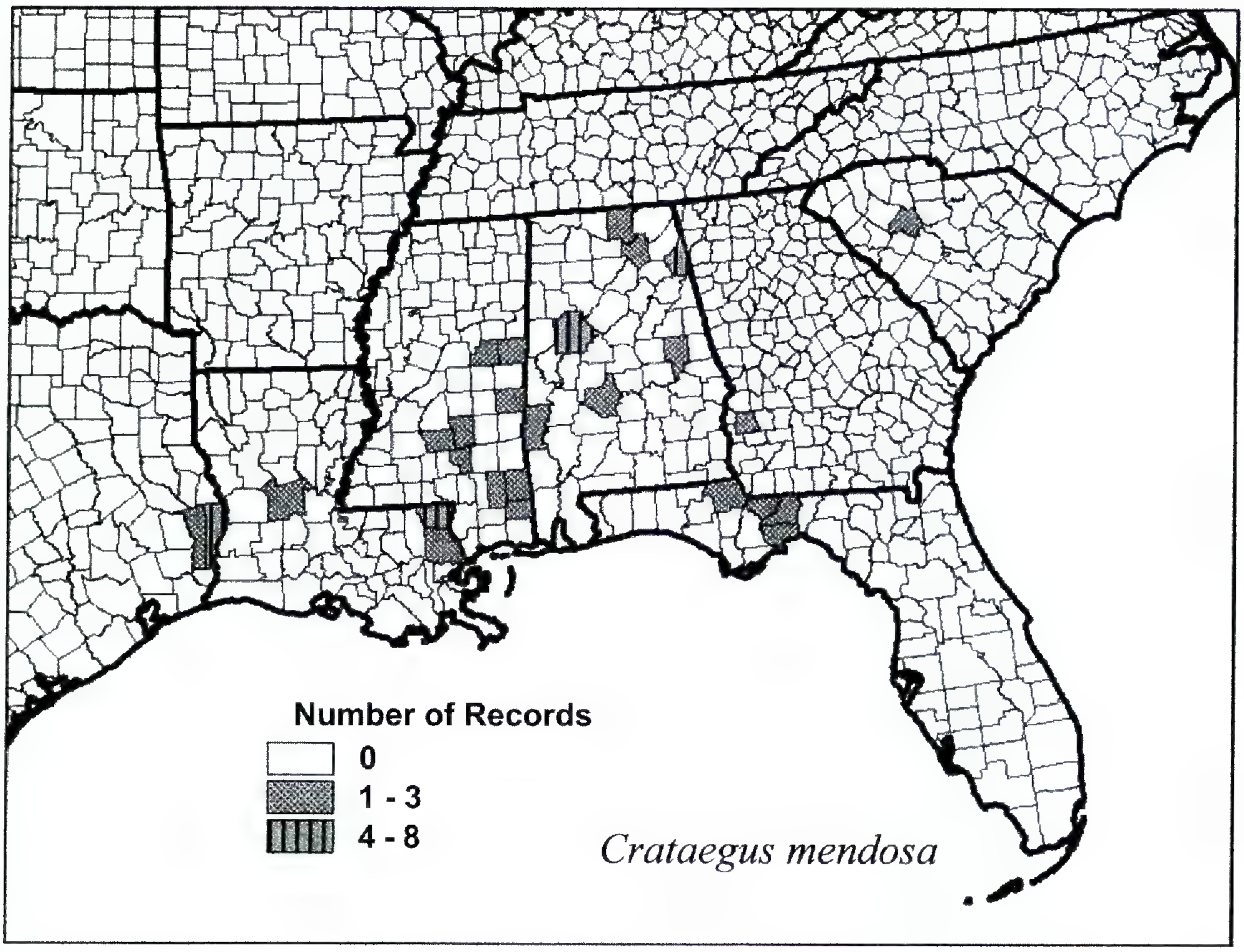


FIG. 7. County level distribution map of *Crataegus mendosa* from collated records.

?=*Crataegus robur* Beadle, Biltmore Bot. Stud., 1:69.1902. TYPE: U.S.A. FLORIDA. Leon Co.: Tallahasee, 18 Sep 1901, *C.D. Beadle 2051* (LECTOTYPE selected here: A).

Shrubs, 2–4 m tall; extending twigs glabrous, green or reddish-tinged; at 1 yr. reddish-black; at 2 yr. dark gray; thorns at 2 yr. 2–3.5 cm long, blackish, fine, ± straight. Leaves: petioles 1–2 cm long, slender, glabrous, glandular, glands sessile or stipitate; blades 2.5–5.0 cm long in our material, narrow ovate or ± oblong through narrow obovate or narrow rhombic in general shape, with 2–4 shallow obtuse to subacute lobes per side; tips acute, bases cuneate; margins serrate with small teeth, somewhat distant for their size; venation craspedodromous with 4–5(–6) main lateral veins per side; glabrous above except for along the main veins adaxially young, glabrous below; thin. Inflorescences 4—7-flowered with a very short central axis; branches glabrous, bearing plentiful, small, caducous, oblong, membranous, stipitate-gland-bordered bracteoles; anthesis mid-April. Flowers 15–20 mm diam.; hypanthium externally glabrous; calyx lobes 3–4 mm long, narrow-triangular, margins glandular-serrate, abaxially glabrous, tip obtuse; petals ± circular, white; stamens 20, anthers small, pink; styles ca. 3. Fruit in clusters of 2–5, 6–7 mm diam., glabrous, deep yellow sometimes flushed red, occasionally purplish-red; calyx lobes reflexed, on a short collar; nutlets ca. 3, dorsally grooved, sides plane.

Common name.—Beautiful hawthorn.

Habitat and Distribution.—Mississippi to Georgia and northern Florida (Fig. 9). Open, rocky woodlands (JBP) and swamp borders (Beadle), scarce.

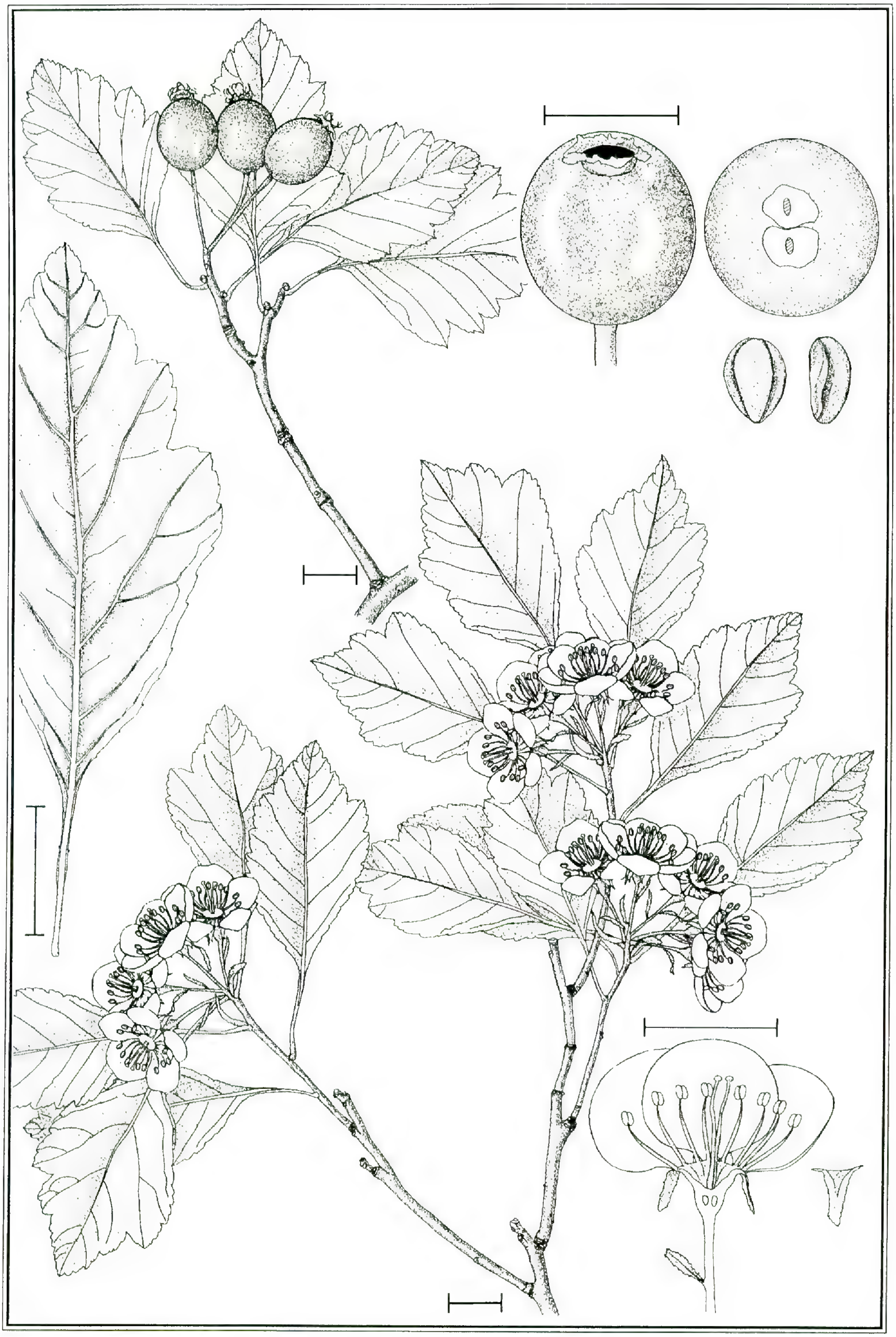


Fig. 8. Line drawing of *Crataegus pulcherrima* from flowering specimen *Norris 705* (IBE) and fruiting specimen *Phipps et al. 8091* (UWO). Scale bars = 1 cm. S. Laurie- Bourque del.

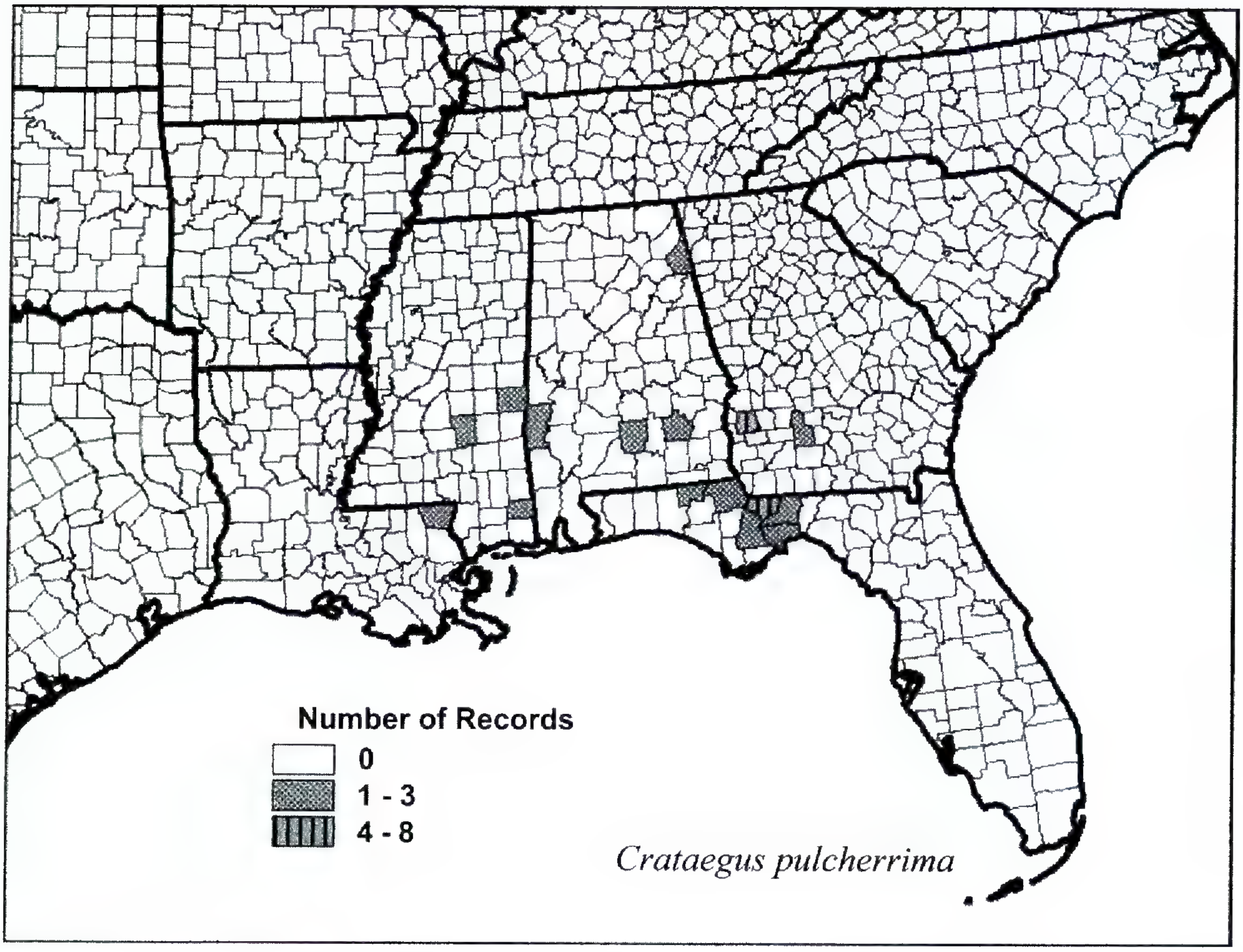


FIG. 9. County level distribution map of *Crataegus pulcherrima* from collated records.

Comment.—The type species of its series was described by Ashe as having 10 stamens but neither of Ashe's co-types (*Nash 2377* and *Nash 2568*) from River Junction, Florida confirm this. This species is usually quite easy to distinguish though occasionally it resembles *Crataegus* cf. *opima*.

5. Crataegus pinetorum Beadle, Bot. Gaz. 28: 343. 1900. (**Fig. 4**). TYPE: U.S.A. ALABAMA. De Kalb Co.: De Soto State Park, 25 Sep 2001, *R. Lance 2174* (NEOTYPE selected here: UWO; ISONEOTYPES: Anniston Nat. Hist. Mus., UNC, JSU).

Shrubs or small trees 2–6 m tall; extending twigs glabrous, with a strong reddish cast; at 1 yr shiny reddish-brown; dull gray-brown at 2 yr; older dull gray; thorns usually present, mainly 2–3.5 cm long, fine, ± straight, shiny black or reddish-black at 1 yr, becoming black. Leaves: petioles 25–30% of leaf blades, glabrous, sparsely to densely glandular or even stipitate-glandular, abaxially grooved; blades 4–6 cm long, nearly full-grown at anthesis, narrowly ovate to elliptic in general shape; tip acute, base cuneate; lobes usually 2–3 per side, fairly shallow (max. LII 10–20%), acute; marginal teeth extremely small, acute; venation craspedodromous, main lateral veins 5–6 per side; glabrous adaxially and abaxially. Inflorescences 2–4-flowered; branches glabrous, bearing plentiful, ± persistent, very narrowly obovate, chartaceous to subherbaceous, densely gland-margined bracteoles. Flowers at anthesis not known; hypanthium externally glabrous; calyx lobes ca. 6 mm long, narrow triangular, margins finely glandular-serrate, abaxially glabrous; petals not known; stamens 20, anther color not known; styles porly persistent. Fruit 12–

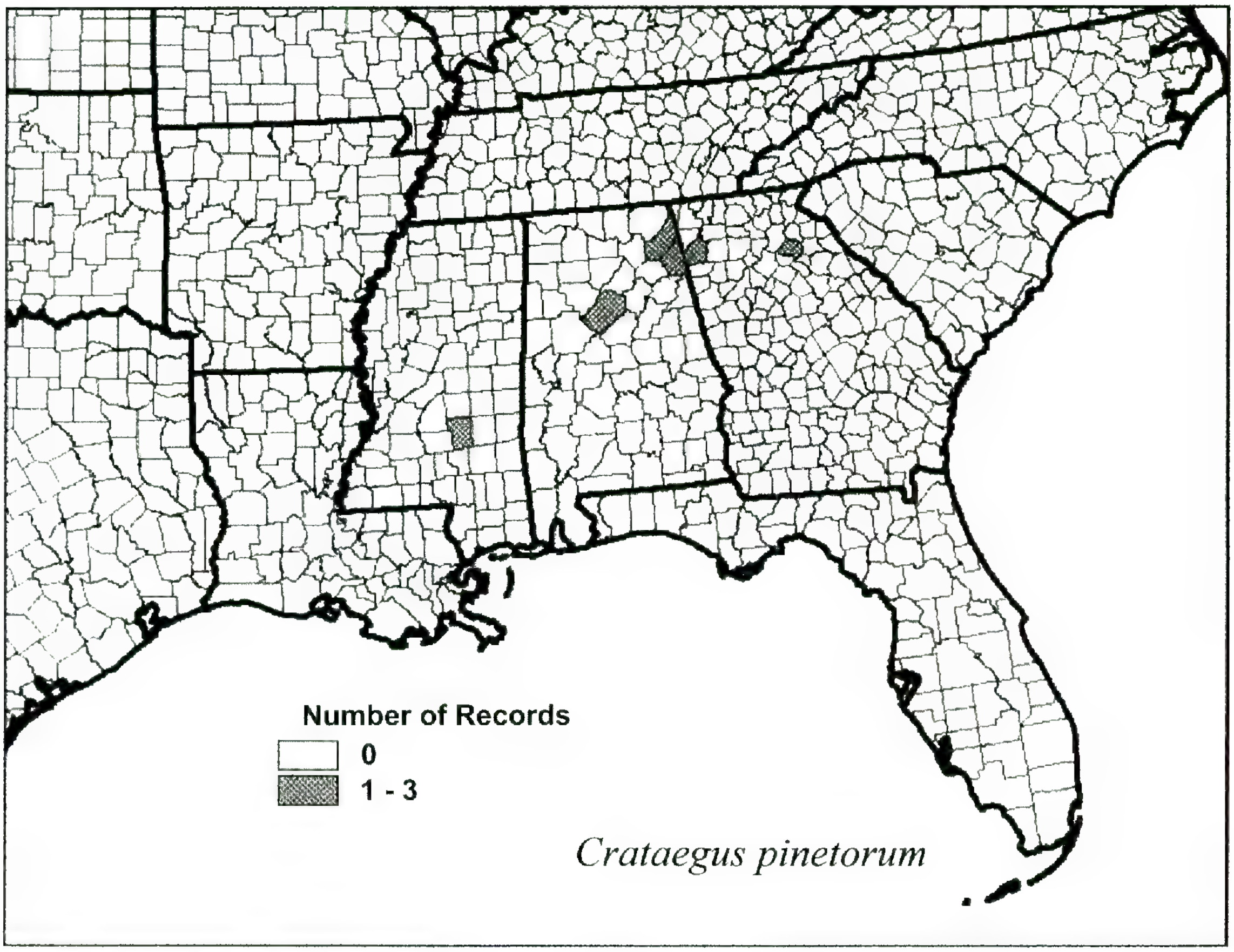


Fig. 10. County level distribution map of *Crataegus pinetorum* from collated records.

14 mm long, subglobose, dull red; calyx lobes erose on only specimens with mature fruit; nutlets 2–4, dorsally grooved, sides plane.

Habitat and Distribution.—*Crataegus pinetorum* is found in woodland edges and gaps, from south-central Mississippi through Alabama to northern Georgia (Fig. 10). It appears to be scarce.

Comment.—I have been unable to locate Beadle's original material of this species, for which no Type was designated and which were from Marshall Co., Alabama. Nor were any specimens labeled '*pinetorum*' in Beadle's hand seen so the species, as understood here, while it does not disagree with the protologue, could be different from Beadle's intention and has therefore received an amplified description here. This is now one of the more distinct of the species in ser. *Pulcherrimae* and, at least superficially, appears most similar to *C. pulcherrima*. It differs from that species in its sharply, rather than obtusely, lobed leaves, often densely glandular petioles, exceptionally small leaf marginal teeth and red fruit. It also somewhat resembles the more deeply lobed forms of *C. gilva*. Our flowering material was collected after petal drop, consequently a few important characters are missing from the description.

6. Crataegus venusta Beadle, Bot. Gaz. 28:338. 1900. (**Figs. 11, 16**). TYPE: U.S.A. ALABAMA. Jefferson Co.: Birmingham, no date, but probably Sep or Oct 1900, *C.D. Beadle 2187/2* (HOLOTYPE selected here: US 969379), 20 Apr 1900, *C.D. Beadle 2187* (EPITYPE selected here: US 969378).

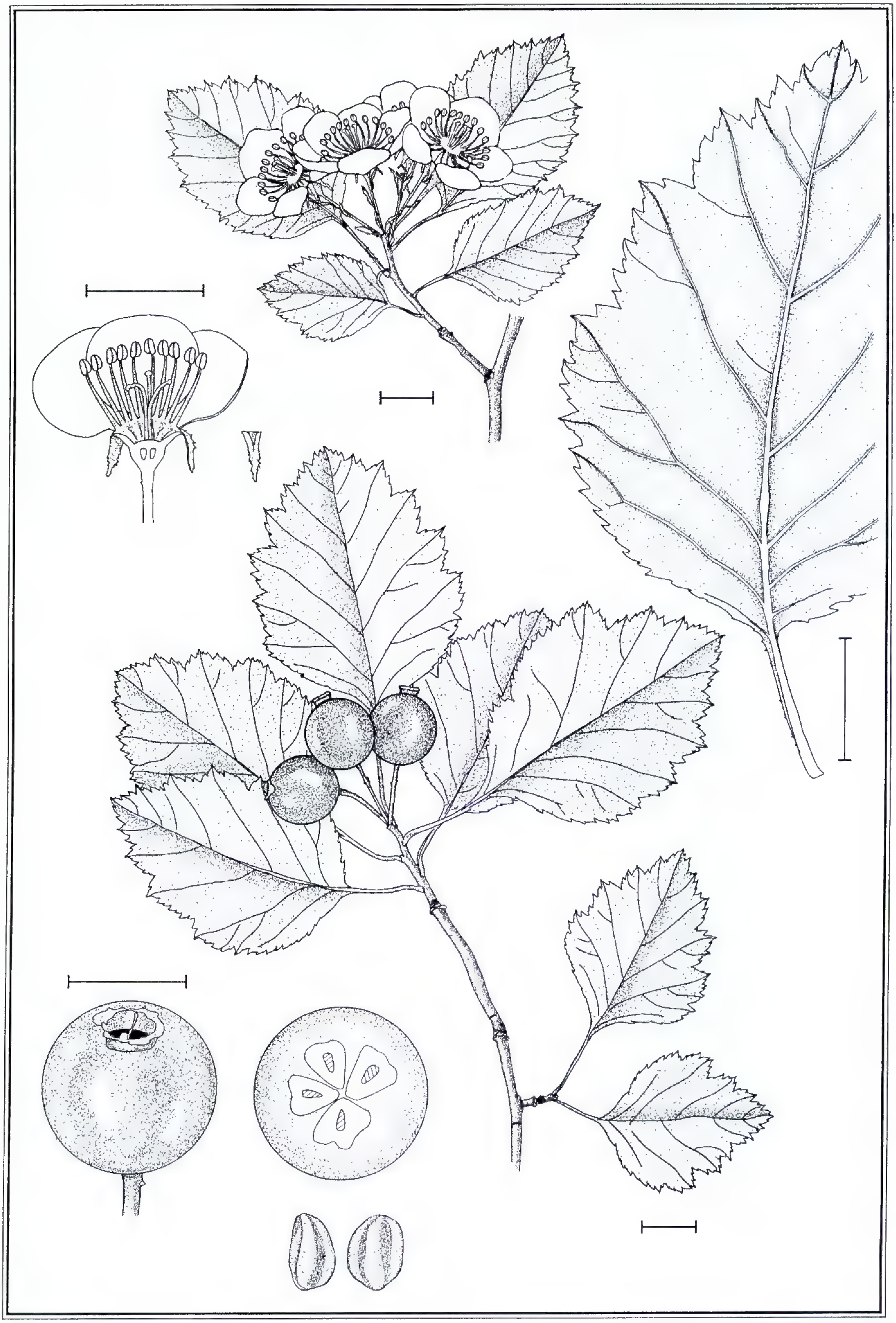


FIG. 11. Line drawing of *Crataegus venusta* from flowering specimen *Phipps & O'Kennon 7936* (UWO) and fruiting specimen *Phipps et al. 8050* (UWO). Scale bars = 1 cm. S. Laurie-Bourque del.

?=*Crataegus pallens* Beadle, Biltmore Bot. Stud. 1:28. 1901. TYPE: U.S.A. NORTH CAROLINA. Buncombe Co.: Biltmore, upland woods, 14 May 1900, *Biltmore Herb. BC2* (LECTOTYPE selected here: US 969397).

?=*Crataegus alma* Beadle, Biltmore Bot. Stud. 1:64. 1902. TYPE: U.S.A. MISSISSIPPI. Lauderdale Co.: Meridian, no date, fruiting specimen; *T.G. Harbison H5147* (LECTOTYPE selected here: US 969433).

Shrubs or small trees 4–7 m tall; one-year twigs often deep chestnut; thorns 2–5 cm long, usually slender, ± straight, very dark at 2-yr old. Leaves: petioles 25–30% length of blade, glabrous, very slender, with sparse sessile glands; blades 5–8 cm long at maturity, broad-oblong to ovate in general shape; base cuneate to broad-cuneate, apex acute to acuminate; shallowly lobed, 0–2 lobes per side, LII very shallow to max. ca. 25%, lobes acuminate young but much blunter in age lobes; margins with numerous, acute to acuminate teeth; venation craspedodromous, 5–7 main lateral veins per side; glabrous except for scattered long hairs adaxially along the mid-vein young. Inflorescences 5–8 flowered; branches glabrous, bearing numerous caducous, narrow-oblanceolate to linear, membranous, clear to greenish, densely gland-bordered bracteoles; anthesis early to mid April. Flowers 15–20 mm diam.; hypanthium ± glabrous; calyx lobes narrow-triangular, glabrous abaxially, finely gland-bordered; petals ± circular, white; stamens 20, anthers pink to purplish (or cream, Beadle); styles 3–4. Fruit 8–10 mm diam., suborbicular, greenish-yellow to yellow (or reddish, Beadle); calyx lobes spreading or erose; nutlets 3–5, dorsally sulcate, laterally smooth.

Habitat and Distribution.—Texas to Georgia, with one record for Tennessee, the second most northerly record for the series (Fig. 12). It is most abundant in Alabama. Brushy forest regrowth, forest gaps and margins.

Comment.—When flowering, *Crataegus venusta* is one of the most striking members of the series with typical oblong leaf blades, their ± lobeless margins bearing numerous acuminate teeth. At maturity this characteristic is diminished and typical larger short-shoot leaves then have several shallow lobes per side, these ± subacute. *Crataegus venusta* was described by Beadle as possessing reddish fruit and cream anthers, but all our material where color determination is possible has yellowish fruit and pink to purple anthers.

The most distinctive taxon attributed to possible synonymy with *C. venusta* is *C. pallens* (syn. *C. alma*), a morphotype with a very sparse and scattered distribution which is found from its type locality in western North Carolina to the type locality of its synonym *C. alma* in Mississippi. Compared to typical *C. venusta* it generally has slightly smaller leaves (blades typically less than 5 cm long), differently shaped lobes that are broader than those of *C. venusta* with leading edge usually ± perpendicular to the midvein and less sharp leaf teeth. If *C. pallens* were to be retained as an accepted species more convincing evidence would be required in view of its odd distribution. Nevertheless, indubitable intermediates with *C. venusta* are not known. For this reason it is listed separately in the appendix of cited specimens.

7. Crataegus opima Beadle, Biltmore Bot. Stud. 1:40. 1901. (**Fig. 13**). TYPE: U.S.A. ALABAMA. Butler Co.: Greenville, 2 Oct 1900, *C.D. Beadle 2159/2* (LECTOTYPE selected here: US 981036); *C.D. Beadle 2159*, fragment only (EPITYPE selected here: NY).

Crataegus abstrusa Beadle, Biltmore Bot. Stud. 1:68. 1902. TYPE: U.S.A. FLORIDA. Leon Co.: Tallahasee, 29 Aug. 1901, *T.G. Harbison H4958 - H4059/2* (LECTOTYPE selected here: US 969425).

?=*Crataegus contrita* Beadle, Biltmore Bot. Stud. 1.61. 1902. TYPE: U.S.A. FLORIDA. Gadsden Co.: River Junction, 3 Apr 1900, *C.D. Beadle 2078* (LECTOTYPE selected here: US 969333).

Crataegus illustris Beadle, Biltmore Bot. Stud. 1:68. 1902. TYPE: U.S.A. MISSISSIPPI. Lauderdale Co.: Meridian, - Sep 1901, *T.G. Harbison H5082 - 4200/2* (LECTOTYPE selected here: US 981041).

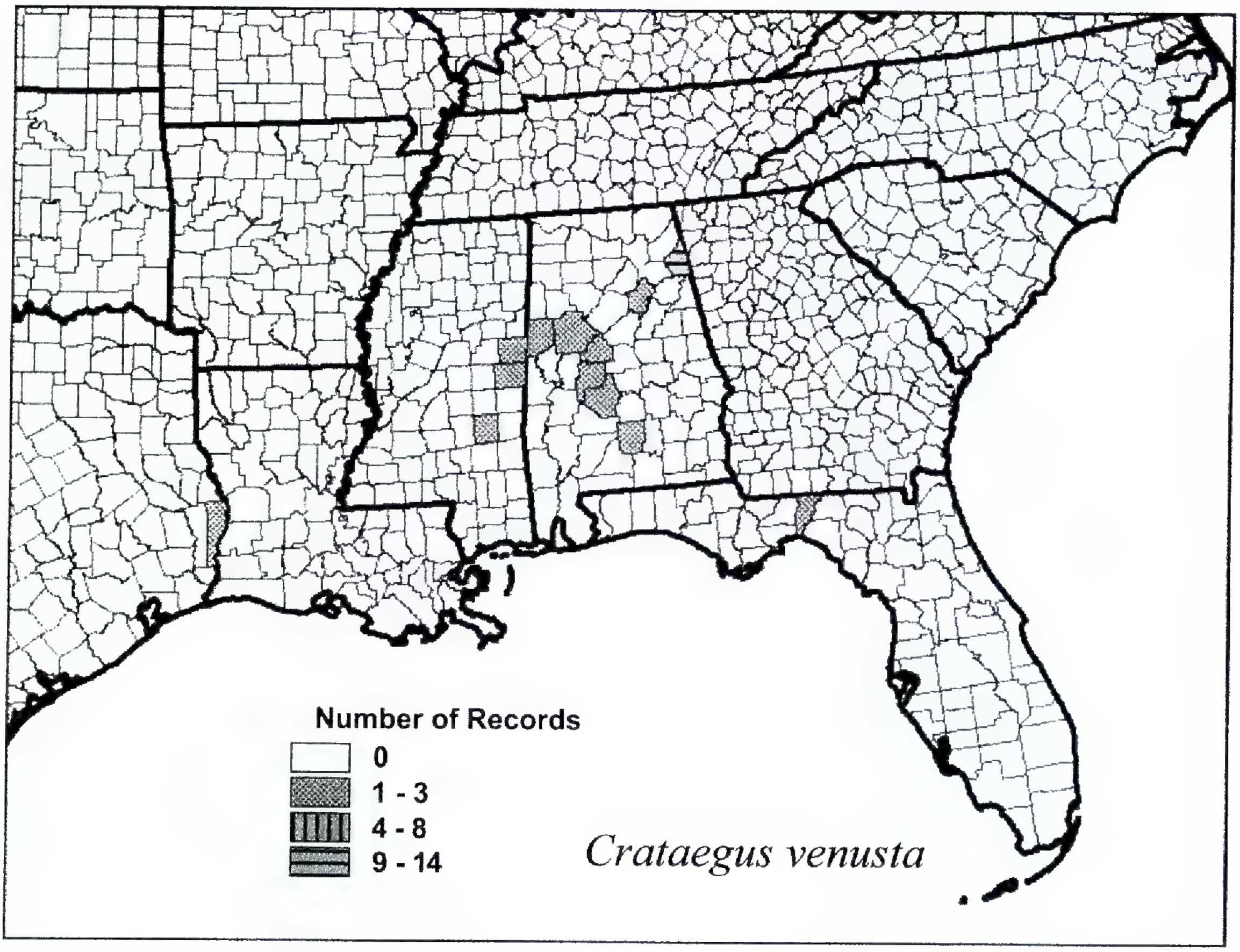


FIG. 12. County level distribution map of *Crataegus venusta* from collated records.

Crataegus inanis Beadle, Biltmore Bot. Stud. 1:62. 1902. TYPE: U.S.A., ALABAMA. Marshall Co.: near Albertville, 8 May 1901, *T.G. Harbison H4306* (LECTOTYPE selected here: US 969437).

?= *Crataegus lenis* Beadle, Biltmore Bot. Stud. 1:67. 1902. TYPE: U.S.A., ALABAMA. Butler Co.: Greenville, no date, fruiting specimen, *C.D. Beadle 2153/2* (LECTOTYPE selected here: US 969429).

Large shrubs or trees to 7 m tall; extending twigs glabrous, reddish-brown, at one year blackish-brown, older gray; thorns none to frequent, 2.5–4.0 cm long, slender, dark brown to blackish at 2-yr old. Leaves: petioles 20–30% length of blade, glabrous, with sparse short-stipitate glands; blades 3–5 cm long, mainly broad-ovate to somewhat deltate in general shape; base cuneate to broad-cuneate, apex subacute to obtuse; 3–4 main lobes per side, the lobes usually ± blunt, very shallow to max. LII ca. 20%; margins with small subacute teeth; venation craspedodromous, with 4–5 main lateral veins per side; sparsely pilose on the mid-vein above when young, glabrous below. Inflorescences 4–7 flowered; branches glabrous or sparsely pilose, bearing caducous, narrow-oblong (sometimes curved), membranous to green, gland-bordered bracteoles; anthesis early to mid April. Flowers 16–18 mm diam.; hypanthium ± glabrous; calyx lobes 4 mm long, triangular, glandular-serrate at the tip; petals ± circular, white; stamens 20, anthers cream to pale or deep purple; styles 3–5. Fruit 7–12 mm long, ± orbicular, yellow or red; calyx lobes erose, or reflexed, sitting on a slight collar; nutlets 3–5, dorsally sulcate, laterally smooth.

Habitat and Distribution.—Extreme southeastern Texas to Georgia, with over half the records from Alabama (Fig. 14), this is the most abundant member of the series. It is found in open woods and woodland margins. Figure 14 maps *C. opima* and *C.* cf. *opima* (sp. 7a) as one.

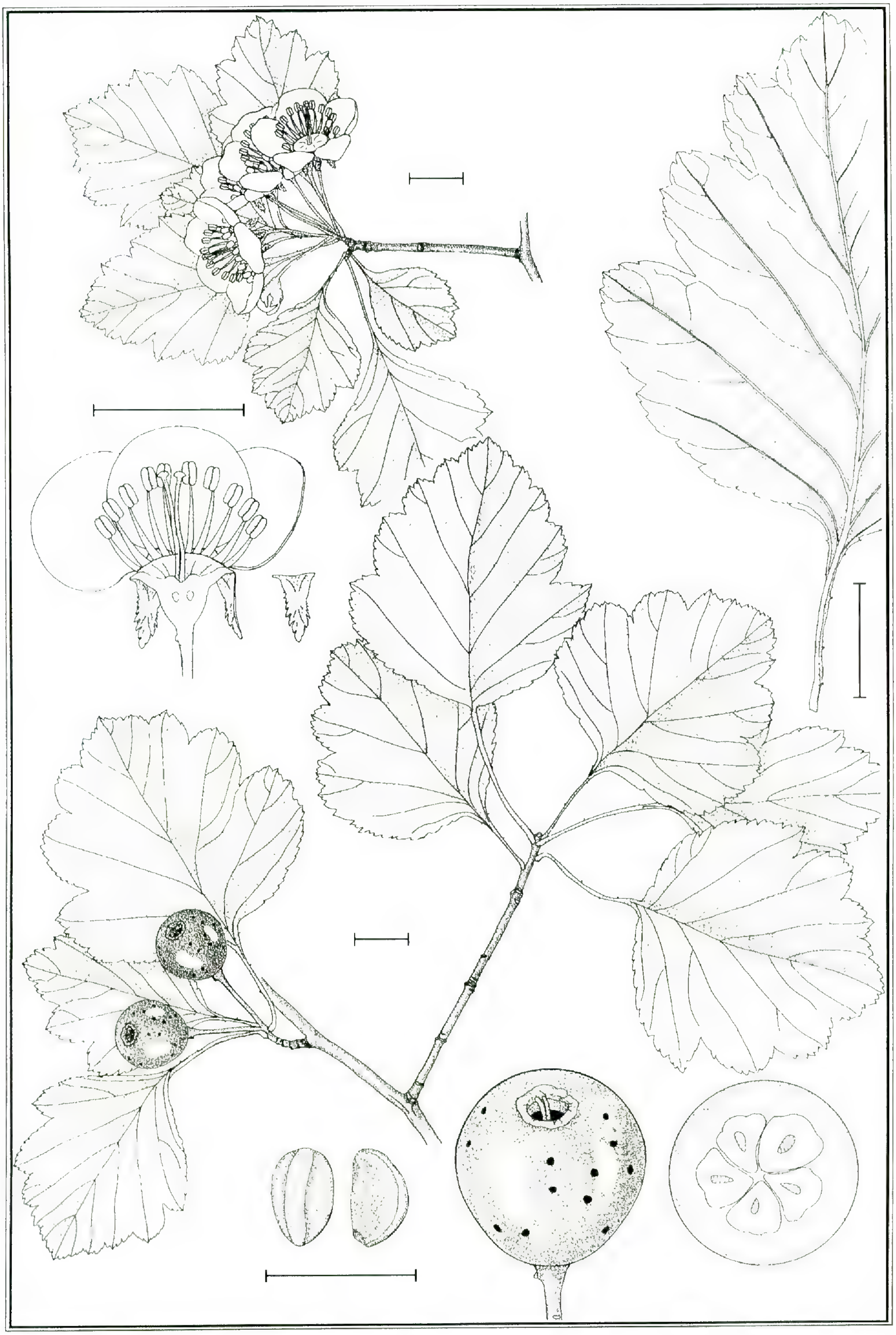


FIG. 13. Line drawing of *Crataegus opima* from flowering specimen *Godfrey 80540* (UWO), fruiting specimen *Phipps & O'Kennon 8089* (UWO) and sterile specimen *Phipps & O'Kennon 8099* (UWO). Scale bars = 1 cm. S. Laurie-Bourque del.

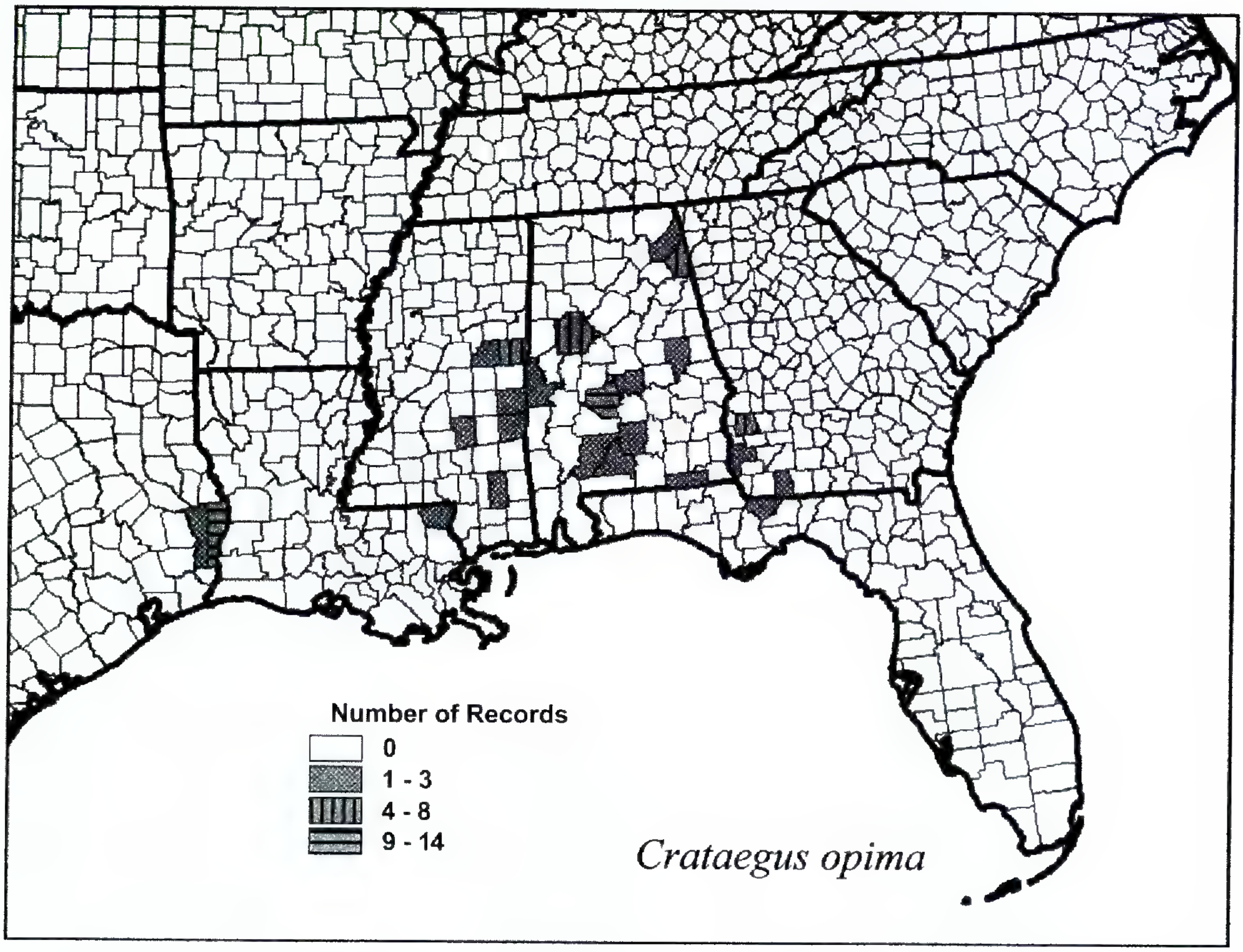


FIG. 14. County level distribution map of *Crataegus opima* and *C. cf. opima* combined from collated records.

Comment.—The species as defined here comprises all the smaller leaved members of the series with broadly proportioned leaves and ± blunt lobing. These tend to have few and fairly shallow lobes. Both red and yellow-fruited forms are known as are forms with cream or purple anthers. It is possible that, as elsewhere in the series, these forms should be recognized as distinct taxa, but more detailed study would be required to authenticate this.

7a. Crataegus cf. **opima** Beadle (**Fig. 15**).

Assigned here are all *opima* like individuals with ovate to ovate-trullate leaves, 5–7(–8) lateral veins per side and 5–8 usually short lobes per side with leaves 5–8 cm long. Forms with these larger multiveined leaves may also have acute lobes. More material and further study is required to see whether this should be recognized as a distinct species.

Note that Figure 14 maps this species and the previous as one and that the list of cited specimens (see Appendix) lists only those specimens of this species which are at UWO. All these are from Alabama and Missisippi but this entity is undoubtedly much more numerous and widespread than this would indicate.

8. Crataegus tecta Beadle, Biltmore Bot. Stud. 1:26. 1901. (**Fig. 16**). TYPE: U.S.A. ALABAMA. Marshall Co.: near Albertville, 7 May 1900, *T. G. Harbison 2205* (LECTOTYPE selected here: US 969434). The flowering fragment of *Harbison 2205* at NY displays well the characteristic lobing of the species. However, the fruiting co-type at US (*T.G. Harbison 3285*) appears to be *C. venusta* as does the fruiting specimen at NY.

?-*Crataegus austrina* Beadle, Biltmore Bot. Stud. 1:59. 1902. TYPE: U.S.A. ALABAMA. Butler Co.: Greenville, no date, fruiting *C.D. Beadle 2151* (LECTOTYPE selected here: US 969395).

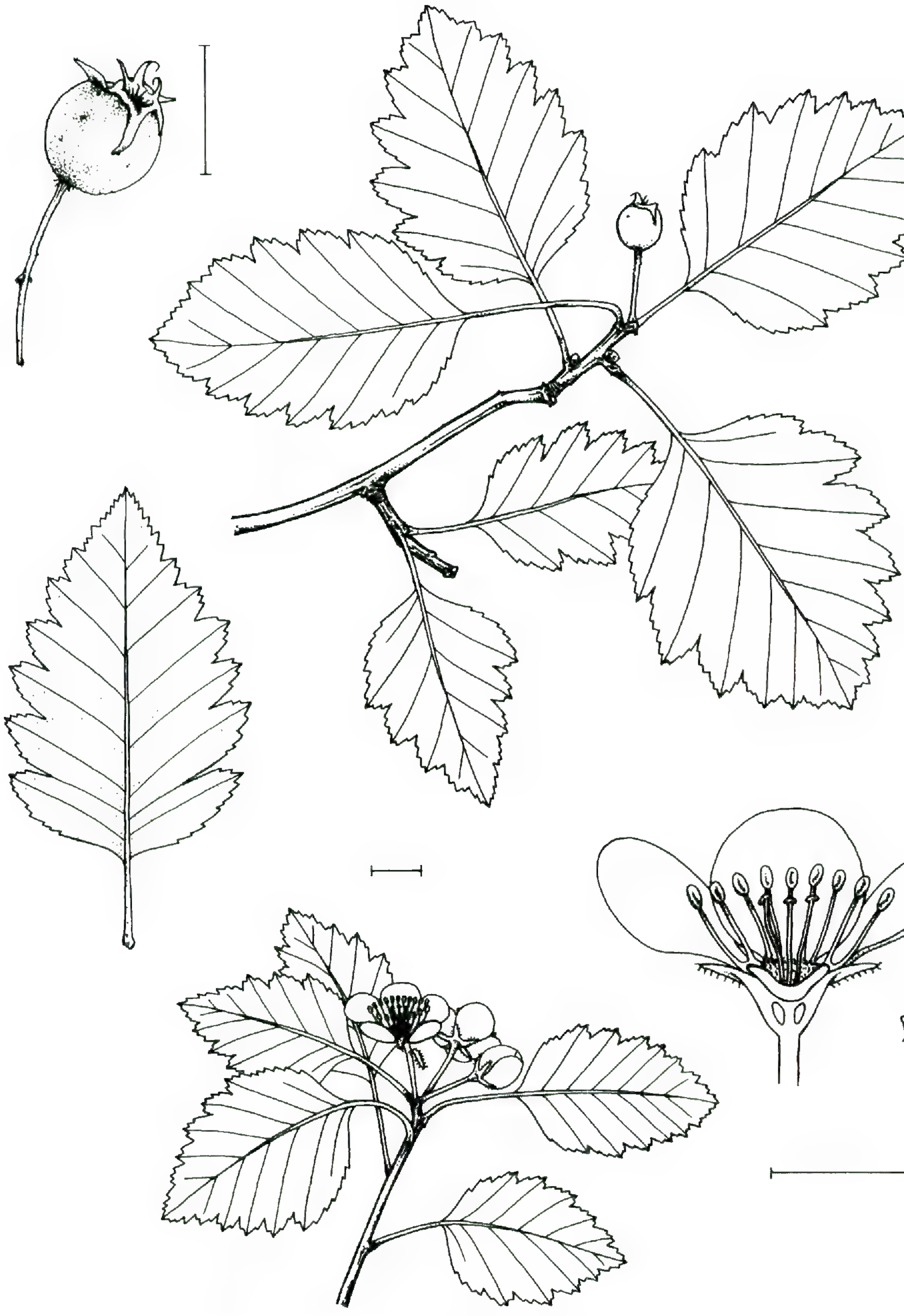


Fig. 15. Line drawing of *Crataegus* cf. *opima* from flowering specimen *Phipps 7930* (UWO), fruiting specimen *O'Kennon 14457* (UWO) and leaf from *Phipps 7795* (UWO). Scale bars = 1 cm. R. Bremmer del.

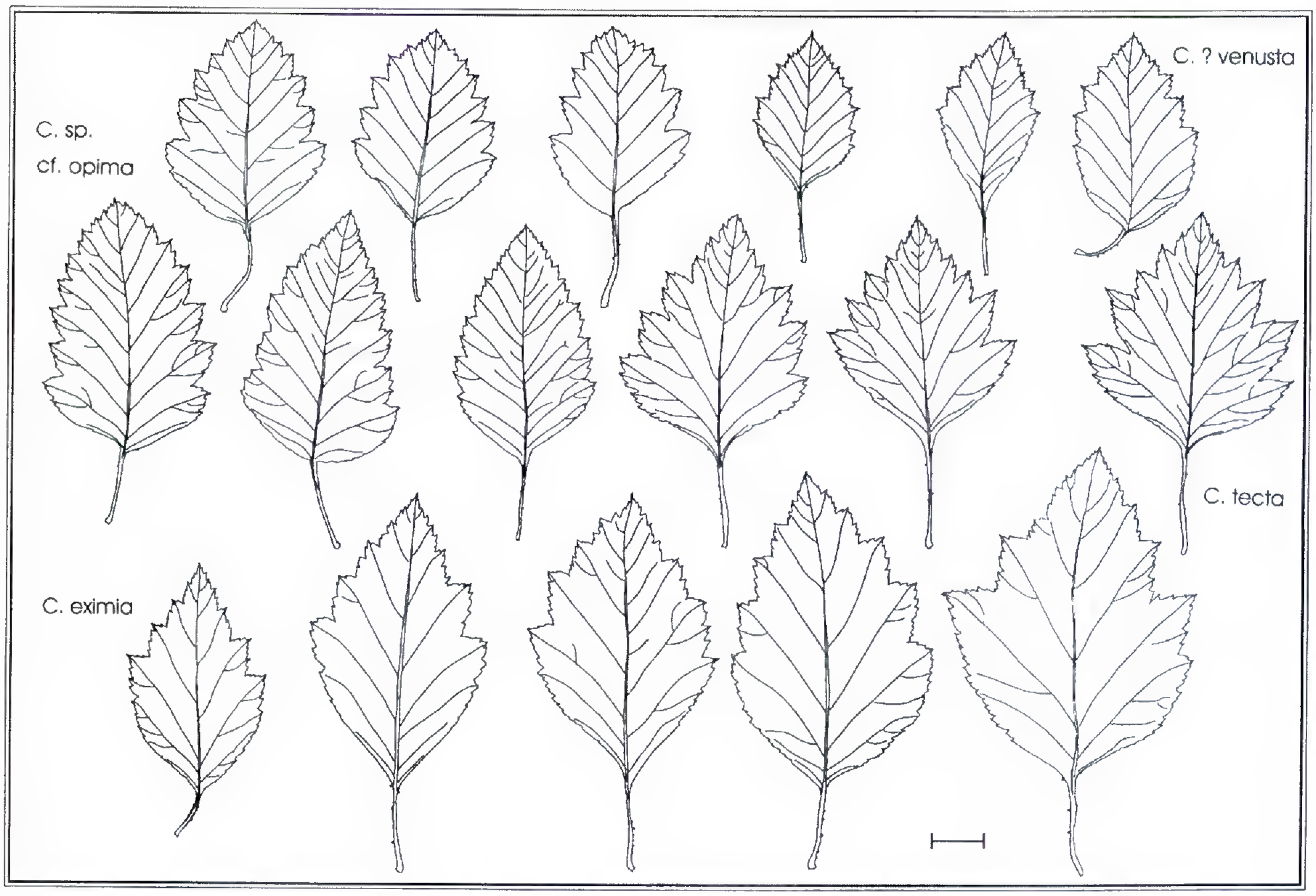


FIG. 16. Line drawing of leaf spectra of: *Crataegus* cf. *opima* from *Cooley et al. 3174* (UWO)—top row, left three; *C.* cf. *opima* from *Phipps & O'Kennon 8069* (UWO)—middle row, left three; *C. ?venusta* from *Ulf Hansen 029* (UWO)—top row, right three; *C. tecta* from *Harbison 2205* (US)—middle row, right three; *C. eximia* from *Harbison H4481*(A)—bottom row, all. Scale bars = 1 cm. S. Laurie- Bourque del.

?=*Crataegus ancisa* Beadle, Biltmore Bot. Stud. 1:63. 1902. TYPE: U.S.A. MISSISSIPPI: Lauderdale Co.: Meridian, 16 Sep 1901, *T.G. Harbison H5092* (LECTOTYPE selected here: US 969424).

Crataegus macilenta Beadle, Biltmore Bot. Stud. 1:64. 1902. TYPE: U.S.A. ALABAMA. Marshall Co.: Albertville, 7 Oct 1901, *T.G. Harbison H5203- H4283/2* (lectotype selected here: US 969432).

Shrubs or small trees 4–6 m tall; bark of trunk not recorded; extending shoots glabrous, at 1-yr dark shiny reddish-black, older dull gray; thorns 2.5–4 cm long, ± straight, ± fine, at 2 yr shiny reddish-black. Leaves: petioles 30–50% length of blade, glabrous, channeled above, with a few sessile glands; blades 3–6 cm long, trullate to rhombovate or ovate in general shape, some times broadly so; apex subacute, base wide cuneate to cuneate; usually fairly deeply (max. LII 20–50%) 3–4 lobed per side, the lobes acute or acuminate to somewhat cuspidate, the larger sharper; margins with small acuminate teeth except at the base; venation craspedodromous, with 4–5 main lateral veins per side; glabrous above except along the main veins when young, glabrous below. Inflorescences 3–6 flowered; branches normally glabrous, beset with numerous caducous, sublinear and often wider near the apex, sometimes curved, membranous to ± herbaceous, gland-margined bracteoles. Flowers 17–19 mm wide; hypanthium externally glabrous; calyx lobes ca. 7 mm long, narrow-triangular, subentire or with margins glandular-denticulate; petals ± circular, white; stamens 20, anthers pale pink to purple or occasionally ivory to cream (see discussion); styles 3–5. Fruit ca. 7 mm long, ± globose, red or green to yellow at maturity (see discussion); calyx lobes reflexed; nutlets 3–5, dorsally grooved, laterally smooth.

Habitat and Distribution.—*Crataegus tecta* occurs from Mississippi to western Georgia, with several records for northern Florida (Fig. 17). It is fairly common in southern Alabama and is found in woodland gaps and edges, and brushy places.

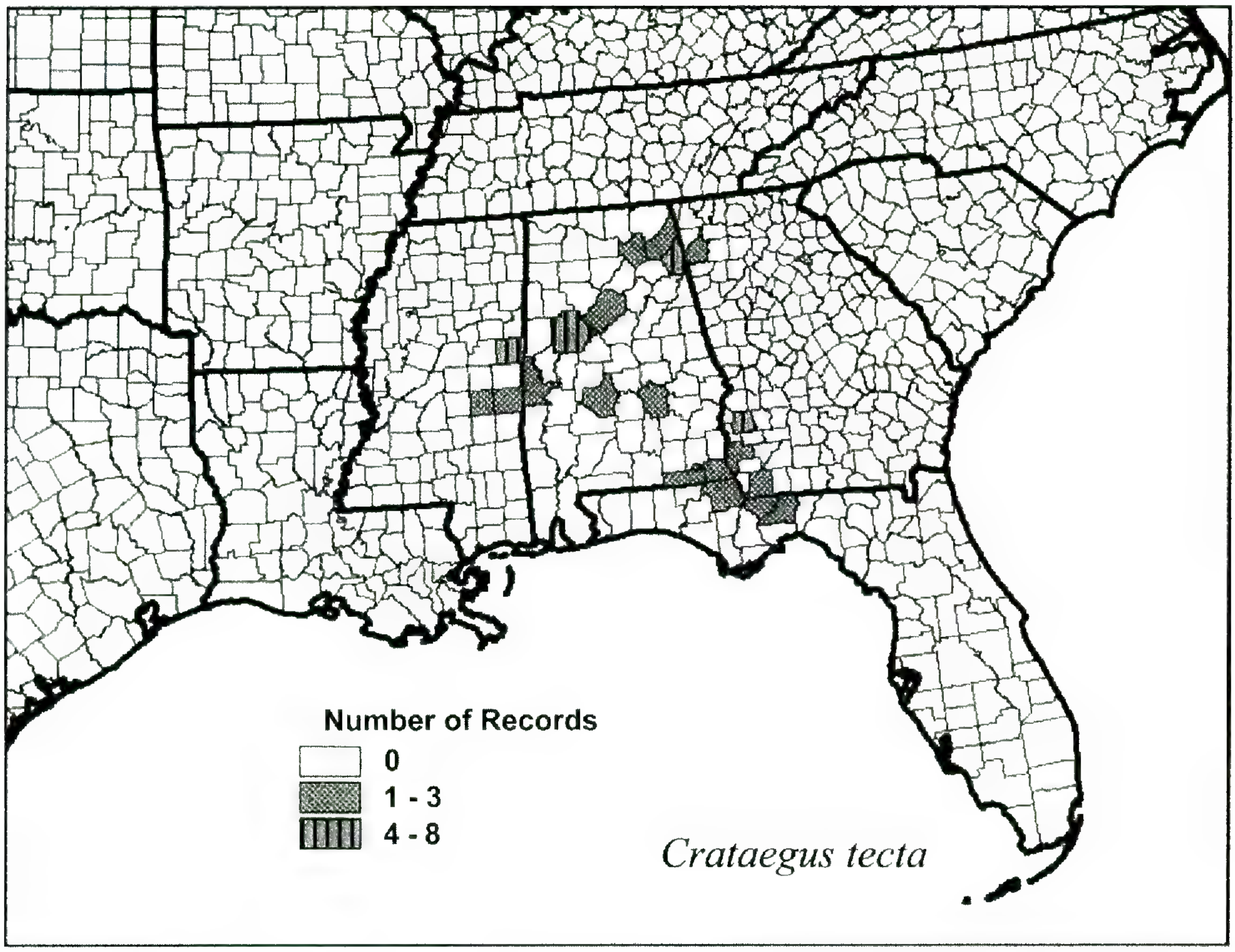


Fig. 17. County level distribution map of *Crataegus tecta* from collated records.

Comment.—The type material of *C. tecta* is of the form represented by the right hand three leaves in the middle row of our figure. This is a very distinctive morphotype in series *Pulcherrimae*. One specimen of *C. tecta* has a fairly densely pubescent inflorescence. If correctly idetified, this is the only such example for the series. *Crataegus ancisa* and *C. macilenta* are both recorded by Beadle as having red fruit and pink to purple anthers but do not differ in other respects. *Crataegus tecta* is most like *C. opima* but with deeper and sharper lobes. Compared to *C. incilis* the latter species the leaves are proportionately narrower, have more lateral veins and the anthers not cream or ivory. Some specimens with deepish lobing, conspicuously acuminate and slightly reflexed lobes are provisionally referred here rather than to *C. venusta*. *Crataegus opima* is the most generally similar species to *C. tecta*, lobe size and shape being the main discriminators. The dubious attribution of *C. austrina* as a synonym is because the lectotype is quite like 7a, *C.* sp. cf *.opima* and the flowering co-type is rather like *C. pallens*. In the case of the *C. ancisa* lectotype, this is one of the few unequivocally intermediate specimens encountered, and it is between *C. opima* and *C. tecta*.

9. Crataegus incilis Beadle, Biltmore Bot. Stud. 1:41. 1901. (**Fig. 18**). TYPE: U.S.A. ALABAMA. Autauga Co.: Evergreen, 12 Apr 1900, *C.D. Beadle 2143* (LECTOTYPE selected here: US 969493).

Crataegus concinna Beadle, Biltmore Bot. Stud. 1:70. 1902. TYPE: U.S.A. FLORIDA. Liberty Co.: Bristol, 2 Apr 1901, *T.G. Harbison H4040* (LECTOTYPE selected here: US 981039).

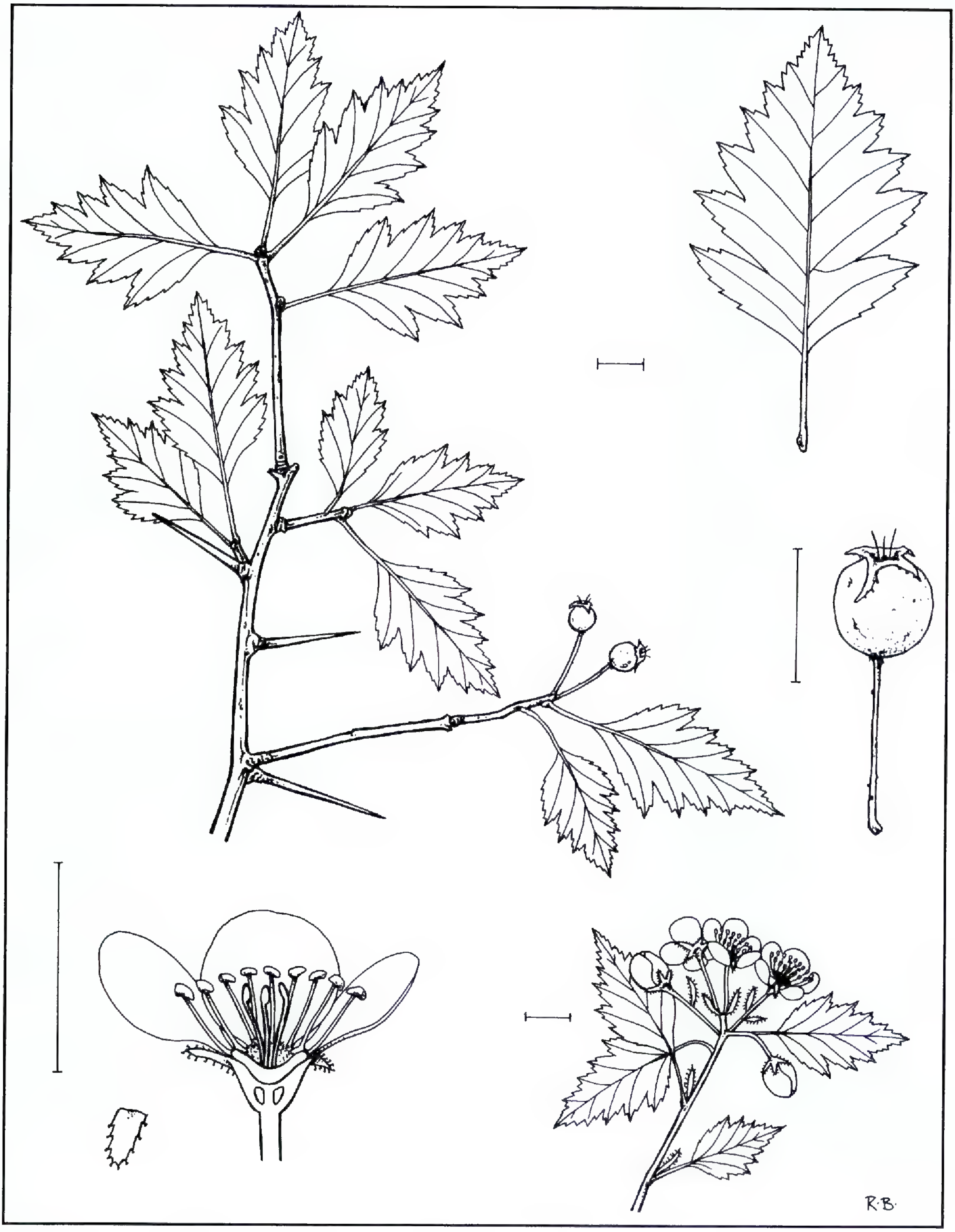


FIG. 18. Line drawing of *C. incilis* from flowering specimen *Phipps 7891* (UWO), fruiting specimen *Phipps 8039* (UWO) and single leaf *Phipps 7844* (UWO). Scale bars = 1 cm. R. Bremmer del.

Shrubs or small trees 4–7 m tall; 1-yr old twigs dark red brown, at 2 yr dark gray; thorns 1.5–3 cm long. Leaves: petioles 1.5–2.5 cm long, slender, glabrous, with few to several sessile glands; blades 3.5–5.5(–7.5) cm long, trullate to narrow-ovate in general outline; subacute at tip, base cuneate, then tapering into the upper winged part of the petiole; 3–4 lobes per side with max. LII 15–40%, lobes usually ± narrow-cuspidate; margins with small some-

what distant subacute teeth; venation craspedodromous, with about 5–7 pairs of lateral veins/side; glabrous on both sides at maturity. Inflorescences 3–7 flowered; branches glabrous; bracteoles abundant, caducous, linear, membranous, gland-margined. Flowers 14–18 mm diam.; hypanthium glabrous; calyx lobes ca. 7 mm long, narrow triangular, margins subentire to glandular-denticulate; petals white, ± circular; stamens 20, anthers pink; styles 3–5. Fruit 5–8(–10) mm diam., globose, red or yellow; calyx lobes wide-spreading; nutlets 3–5, dorsally grooved, laterally smooth.

Habitat and Distribution.—Most of our records are from northeastern Alabama, but it is known from Mississippi to southwestern Georgia and northwestern Florida (Fig. 19). *Crataegus incilis* is found in open woods and woodland margins.

Comment.—The deeply cut trullate leaves, with the acute tips of their triangular lobes in a ± straight line in the more extreme forms, as in our illustration, are very distinctive. The Type, and most specimens seen, however, do not have quite such nearly straight-sided lobes as seen in the illustration and their lobes may be described as ± narrow cuspidate. Forms with somewhat more rounded lobes and yellow fruit are perhaps represented by *C. concinna*. However, it should be noted that the fruiting co-types of *C. concinna* at US (both *H4040/2*) appear to be a different species, one with barely lobed leaves. The delicate leaves and twigs of this species are peculiarly attractive.

10. Crataegus eximia Beadle, Biltmore Bot. Stud. 1:62. 1902. (**Fig. 16**). TYPE: U.S.A. ALABAMA. Jackson Co.: Sand Mountain, near Pisgah, 6 May 1900, *T.G. Harbison 4448* (LECTOTYPE selected here: A).

Shrubs or small trees 3–4 m tall; 1-year old twigs reddish-brown; older gray; thorns 3–4 cm long, usually fine, slightly curved, at 2 yrs. blackish-gray. Leaves: petiole 25–40% length of blade, glabrous, adaxially grooved, densely beset with stipitate glands, at lest young; blades mainly 4.5–6.5 cm long at anthesis, to 8 cm at maturity, ovate-rhombic to ovate-trullate; 3–4(–5) lobes per side, these subacute to acute, max LII usually 20–33%; margins finely dentate; venation craspedodromous, 5–6 main lateral veins per side; abaxial surface scabrous-hairy only along main veins when young, glabrous below. Inflorescences 4–6 flowered; branches glabrous, bearing caducous, very narrowly obovate, ± membranous, gland-margined bracteoles. Flowers 22–25 mm diam.; hypanthium glabrous; calyx lobes 4–5 mm long, finely glandular-serrate, glabrous on both sides; petals ± circular, white; stamens ca. 20, anthers cream; styles 3–4. Fruit (Beadle) 8–12 mm wide, globose, at maturity reddish; nutlets 3–5 (Beadle), dorsally grooved.

Habitat and Distribution.—Rocky woods and glades, Sand Mountain, Jackson Co., Alabama (Fig. 20).

Comment.—Known to me (JBP) only from a flowering co-type, this nevertheless seems one of the most distinct entities in the series on the basis of its large rhombovate leave with deep and angular lobing, large flowers and late to very late flowering date (23 May in 1901). Series *Pulcherrimae* are generally scarce this far north.

APPENDIX

Further cited specimens (species, states and counties arrangement alphabetic).

Crataegus gilva Beadle

ALABAMA. Cherokee Co.: Little R. Canyon North Park, 24 Apr 1969, *K.E. Landen & J. Cofield s.n.* (JSU); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42 W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7937a* (UWO); entrance road to Little River Canyon Mouth Park, 33° 17'N, 88° 40.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7922* (UWO); entrance road to Little River Canyon Mouth Park, 34° 17'N, 88° 40.5'W; 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7923* (UWO); Little River Canyon rim road ca. 1 km direct NW from Daniel's Gap, 34° 18'N,

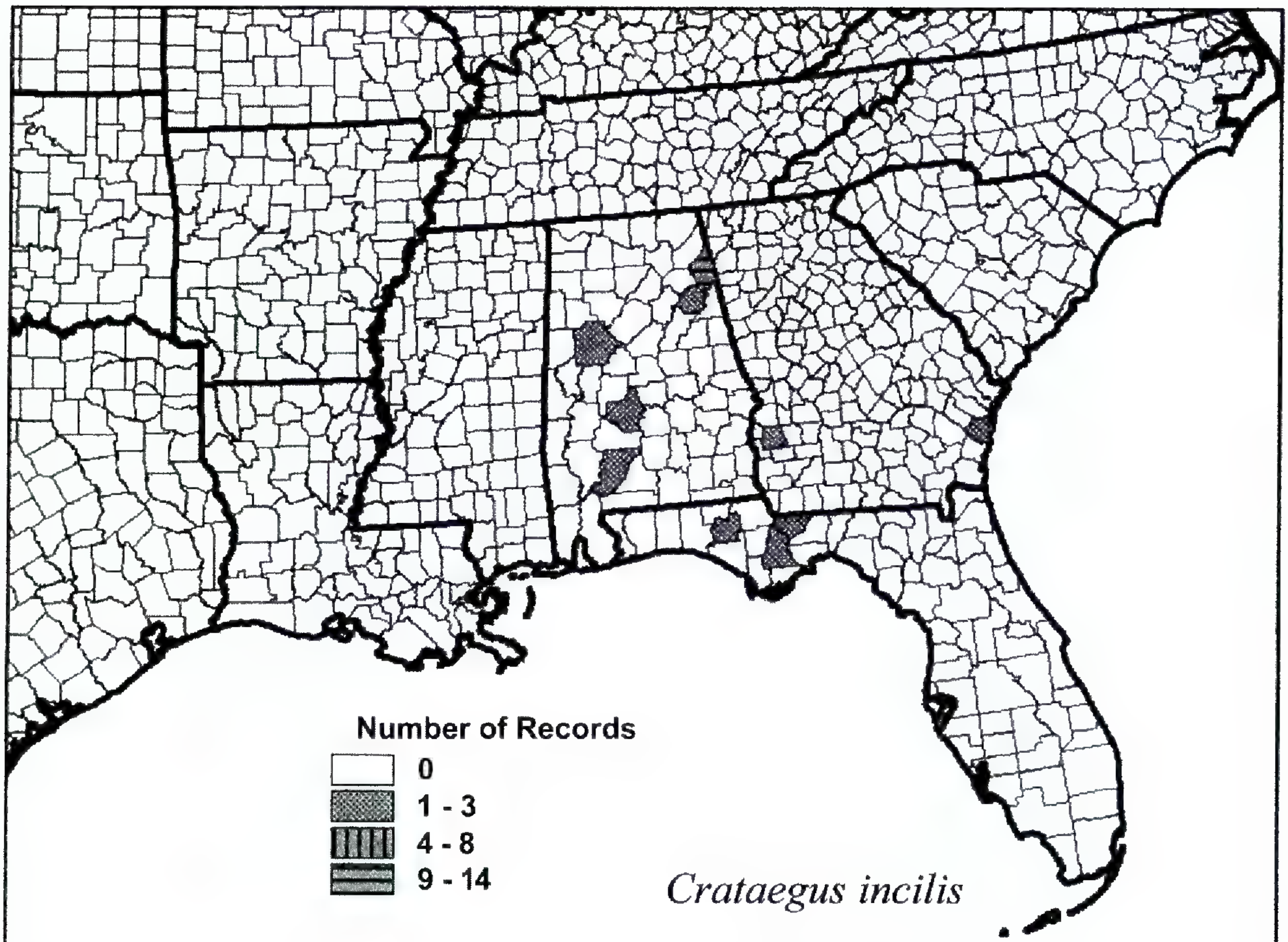


Fig. 19. County level distribution map of *Crataegus incilis* from collated records.

85° 42'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8046* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7940* (UWO). **De Kalb Co.:** Along Little R. in Little R. Canyon, near Eberhart's Point; 20 Apr 1968, *K.E. Landen & J. Cofield s.n.* (JSU); De Soto State Park, campground area, 34° 30'N, 85° 38'W, 19 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7956* (UWO); De Soto State Park, campground area, 34° 30'N, 85° 38'W, 19 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7954* (UWO). **Marshall Co.:** no location, no date, *C.D. Beadle s.n.* (A). **Tallapoosa Co.:** Along Co. Road 2, on hilltop S of Romulus, scrubland on W side of road, 10 Apr 1999, *R. Lance s.n.* (UWO); Co. Rd. 2, 10 km NE of jct. 10 or 51, SE side at gate with big overview opposite, 33° 13'N, 87° 42'W, 13 Apr 1999, *J.B. Phipps 7889* (UWO). **Tuscaloosa Co.:** near Northport Econolodge, wooded bank behind motel, at edge, 33° 14'N, 87° 34'W, 11 Apr 2000, *J.B. Phipps 8118* (UWO).

FLORIDA. Gadsden Co.: Aspalaga, Appalachicola R., 05 Apr 1964, *S. McDaniel 4095* (IBE); Greensboro, 05 Apr 1964, *D. Demaree 49482* (NO). **Jackson Co.:** Three Rivers State Park, road leading to camping area no. 1, 1 mi N of Sneads, 03 June1983, *R.K. Godfrey 80684* (UWO). **Leon Co.:** near Tallahassee, Apr 1843, *Rugel 44* (BM, NY); mesic woodland on bluff by Lake Miccosukee, Ring Oak Plantation, E of Miccosukee, 22 Mar 1983, *R.K. Godfrey 80354* (UWO). **Liberty Co.:** Bristol, Appalachicola R., 24 Mar 1967, *S. McDaniel 8625* (IBE).

GEORGIA. Burke Co.: Rte 56, N of intersection with 80, N of Lake Crystal Rd. to E, 33° 05'N, 82° 05'W, 09 Apr 1991, *J.B. Phipps 6498* (UWO). **Clarke Co.:** Athens, Ag. Campus, Oconee Hillside, 11 Apr 1929, *J.R. Dunnaway E8027* (GA, 2). **Houston Co.:** Oakey Woods Wildlife Management Area, just S of Kathleen, E side of gravel road to check-in station, 0.4 mi S of fork, 32° 28.680'N, 83° 34.667'W, 10 Apr 2001, *R. Lance 2130* (UWO). **Merriwether Co.:** White Sulphur Springs, 26 May 1924, *T.G. Harbison 16307* (UNC). **Rabun Co.:** Tallulah River State Park, near overlook to dam, NE of dam, N 34° 44.429', W 83° 23.655', 26 Apr 2001, *R. Lance 2135* (UWO). **Randolph Co.:** SE of Coleman, ca. 0.5 mi W of Co. Rd. 160, on N side of Co. Rd. 62, across from old drive, 31° 28.630'N, 84° 52.875'W, 09 Apr 2001, *R. Lance 2112* (UWO); SE of Coleman, 0.5 mi W of jct. with Hwy 160 on S side of road, at woods and field corner, near phone box "616-6," 31° 39.898'N, 84° 53.642'W, 10 Apr 2001, *R. Lance 2120* (UWO). **Richmond Co.:** Augusta, sand hills, 20 Apr 1900, *S.T. Olney and J. Metcalf 222* (DOV); Augusta, no date, *A. Cuthbert 2* (GH).

MISSISSIPPI. Greene Co.: roadside in wooded country near McLain on US 98, 31° 07'N, 88° 48'W, 07 Apr

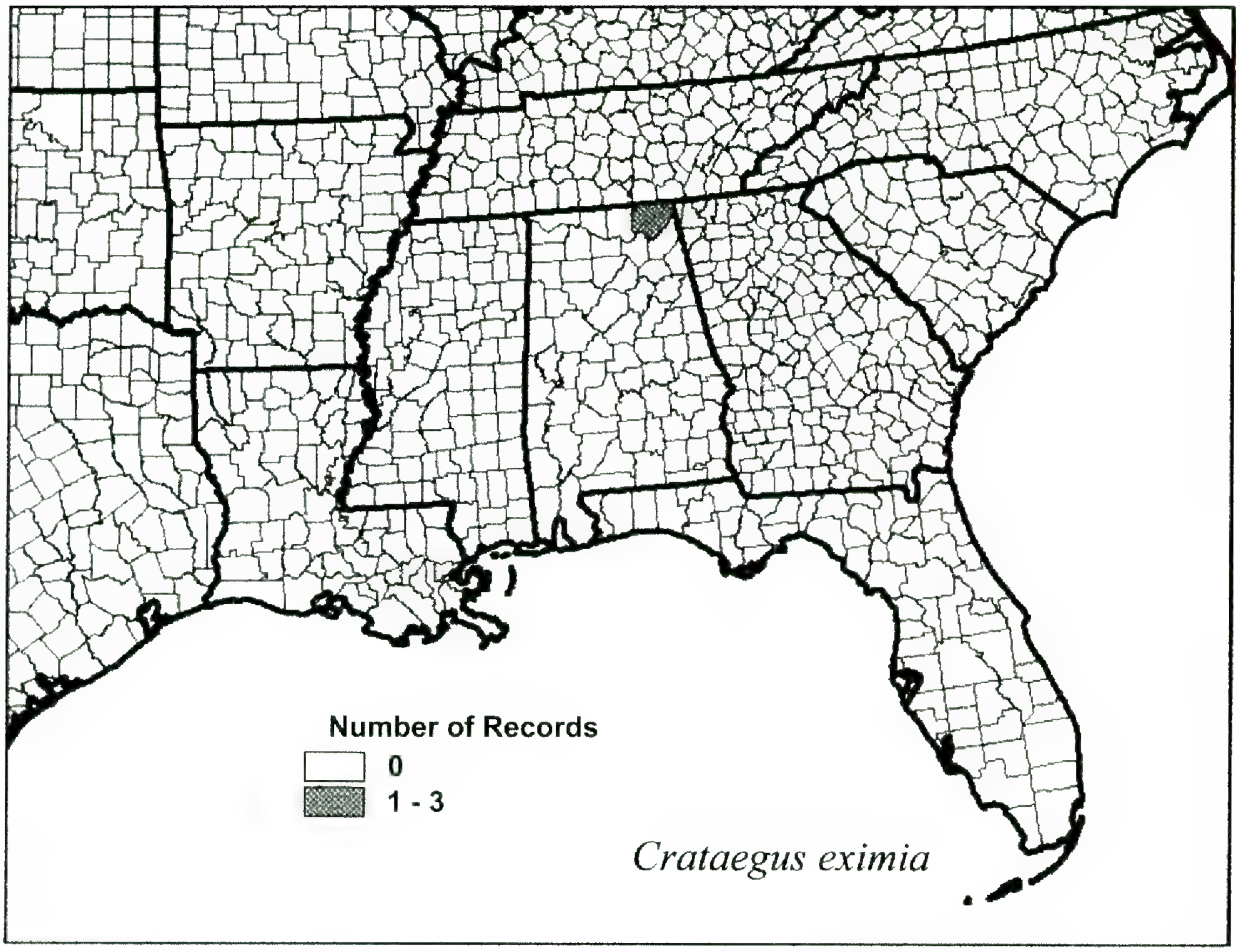


Fig. 20. County level distribution map of *Crataegus eximia* from collated records.

1984, *J.B. Phipps & T.C. Wells 5335* (UWO); roadside in wooded country near McLain on US 98, 31° 07'N, 88° 48'W, 07 Apr 1984, *J.B. Phipps & T.C. Wells 5339* (UWO). **Jones Co.:** Laurel, just N of jct. Tallahoma/Tallahala Creeks, NW4 S35, 02 Apr 1980, *S. McDaniel s.n.* (UNA, UWO). **Lauderdale Co.:** Meridian, 12 Apr 1900, *C.S. Sargent s.n.* (DOV). **Simpson Co.:** Saratoga, 01 Apr 1903, *S.M. Tracy 8490* (MO).

Crataegus incilis Beadle

ALABAMA. Calhoun Co.: Brown Ridge Road, 0.3 mi SW of jct. with county highway 55, scrubby hill E side of Brown Ridge Road, opposite open field, 08 Apr 1998, *R. Lance s.n.* (UWO). **Cherokee Co.:** Little River Canyon rimroad, ca. 1 mi NW of Daniel's Gap, 34° 17'N, 85° 41'W, 08 Oct 1998, *J.B. Phipps 7844a* (UWO); Little River Canyon rimroad, ca. 1 mi NW of Daniel's Gap, 34° 17'N, 85° 41'W, 08 Oct 1998, *J.B. Phipps 7844c* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7939* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 22 1999, *J.B. Phipps & R.J. O'Kennon 8040* (UWO); entrance road to Little River Canyon Mouth Park, 34° 17'N, 88° 40.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7946* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8048* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 22 Apr 1999, *J.B. Phipps & R.J. O'Kennon 8039* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7942* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8045* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7944* (UWO); entrance road to Little River Canyon Mouth Park, 34° 17'N, 88° 40.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7924* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8042* (UWO). **Dallas Co.:** road to Elm Bluff from Shephardville, ca. 1.5 km W of Shephardville, 32° 11'N, 87° 05'W, 24 Apr 1999, *R.J. O'Kennon & R. Lance 14458* (UWO); Elm Bluff, near Alabama River, 32° 11'N, 87° 06'W, 02 Oct 1998, *J.B. Phipps & R. Lance 7795* (UWO). **Monroe Co.:** Haines Island, high limestone ridges along Alabama R., Red Hills area, 05 Apr 1986, *A.R.*

Diamond 2256 (AUA). **Tuscaloosa Co.:** Lake Lurleen State Park, wooded slope near campground, 10 Apr 1999, *R. Lance 66* (UWO).

FLORIDA. Gadsden Co.: Hardin Heights, jct. FL 269 and E extension of Brickyard Rd., 03 Aug 1983, *J.B. Nelson & G.R. Knight 2449* (FSU). **Liberty Co.:** Bristol, 31 Mar 1902, *T.G. Harbison H4040* (A). **Washington Co.:** FL 273, 8 mi S of Chipley, 14 Apr 1966, *J. Beckner & W. D'Arcy 1160* (DUKE).

GEORGIA. Mcintosh Co.: Meridian, 19 Apr 1912, *T.G. Harbison 10859* (NCU).

Randolph Co.: SE of Coleman, ca. 0.5 mi W of Co. Rd. 160, on N side of Co. Rd. 62, across from old drive, N 31° 28.630', W 84° 52.875', 09 Apr 2001, *R. Lance 2111* (UWO); SE of Coleman, ca. 6.7 mi from S end of Rd. 20 and 1.1 mi from jct. with Hwy 160, ca. 20 ft W of road, in young oak woodland, just W of cemetery and telephone cable post "616-12," N 31° 39.708' W 84° 54.131', 09 Apr 2001, *R. Lance 2119* (UWO).

MISSISSIPPI. Smith Co.: SE of Lemon on 35, SR 533A, 32° 07'N, 89° 29'W, 26 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8090* (UWO).

Crataegus mendosa Beadle

ALABAMA. Cherokee Co.: Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34°18'N 85° 42'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7941* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N 85° 42'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7938* (UWO); Little River Canyon Park, just N of Powell Trail access on rim road, 34° 19.729'N 85° 40.232'W, 25 Sep 2001, *R. Lance 2176* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N 85° 42'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7939a* (UWO). **Choctaw Co.:** AL 10, 9 km SE of jct. Co. Rd. 9 (at Lisman), SW side of road, 32° 06'N 88° 15'W, 14 Apr 1999, *J.B. Phipps 7904* (UWO). **Dallas Co.:** road to Elm Bluff from Shephardville, ca. 1.5 km W of Shephardville, 32° 11'N 87° 05'W, 24 Sep 1999, *R.J. O'Kennon & R. Lance 14455* (UWO); road to Elm Bluff from Shephardville, ca. 1.5 km W of Shephardville, 32° 11'N 87° 05'W, 24 Sep 1999, *R.J. O'Kennon & R. Lance 14454* (UWO). **Madison Co.:** Pine Bluff (1315 ft), 10 Apr 1882, *C. Mohr 446* (ALU). **Pickens Co.:** On dirt road joining Fellowship and New Hope churches, 2.2 mi N of Co. Road 30, NW 1/4 Sec 24 T19S R14W, 09 Apr 1977, *L.J. Davenport 22* (UNA). **Tallapoosa Co.:** Approx. 15 mi from Dadeville post office, SSW, 4 mi from Martin Dam, 01 May 1971, *E.J. Widder 096* (AUA); Route 50 ca. 1 km E of Martin Dam, 32° 41'N 85° 53'W, 16 Oct 1984, *J.B. Phipps 5500* (UWO). **Tuscaloosa Co.:** Co. Rd. 2, 5 km NE of jct. 10 or 51, 33° 12'N 87° 43'W, 13 Apr 1999, *J.B. Phipps 7886* (UWO); Co. Rd. 2 at 11 km NE jct. 51 at overlook, 33° 13'N 87° 42'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8068* (UWO); Co .Rd. 2 at 11 km NE jct. 51 at overlook, 33° 13'N 87° 42'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8070* (UWO); Co.Rd. 2 at 11 km NE jct. 51 at overlook, 33° 13'N 87° 42'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8065* (UWO); Co. Rd. 2, 10 km NE of jct. 10 or 51, 33° 13'N 87° 42'W, 13 Apr 1999, *J.B. Phipps 7892* (UWO); Kellytown Rd., 1 km from jct. Valley Rd., 33° 07'N 87° 49'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon* 8073 (UWO).

FLORIDA. Gadsden Co.: River Jct., 06 Sep 1940, *W.A. Murrill 20* (MO). **Jackson Co.:** ca. 9 mi N of Marianna, 21 Oct 1955, *R.K. Godfrey & H. Kurz 54277* (NCSC). **Leon Co.:** 4 mi E of Tallahassee (decid. woods), 16 Mar 1955, *R.K. Godfrey 53022* (USF). **Wakulla Co.:** near Wakulla Springs, 12 Apr 1931, *E.J. Palmer 38571* (MO).

GEORGIA. Randolph Co.: SE of Coleman, ca. 0.5 mi W of Co. Rd 160, on N side of Co. Rd. 62 on margin of private drive, N 31° 28.630', W 84° 52.875', 27 Sep 2001, *R. Lance 2194* (UWO); SE of Coleman, W side of Co. Rd 20 (Cemetery Road), ca. 6 mi from its S end and 1.8 mi from its jct. with Hwy 160, across from pine plantation and "posted" sign, N 31° 39.375', W84° 54.853', 27 Sep 2001. *R. Lance 2182* (UWO); SE of Coleman, 6.2 mi from S end of Rd. 20 and 1.6 mi from jct. with Hwy 160, N 31° 39.468', W 84° 54.642', 27 Sep 2001, *R. Lance 2183* (UWO).

LOUSIANA. Rapides Parish: Lacompte Quad., 09 Jul 1977, *L.E. Urbatsch 3237* (LSU). **St. Tammany Parish:** 4 mi W of Bush, N of La 40, pinewoods, 26 Sep 1975, *R. D. Thomas & C. Allen 47164* (NLU). **Washington Parish:** Bogalusa, 03 Oct 1919, *R.S. Cocks 3151* (NO); woods at Mt. Hermon Cemetery beside La. 450 NW of Mt. Hermon, Sec. 40, T1S, R9E, 14 Jun 1983, *R.D. Thomas 84147* (UWO).

MISSISSIPPI. Covington Co.: 2.5 mi NE of Collins, pine hardwoods, 08 Apr 1961, *L.H. Shinners 29359* (GA). **George Co.:** Pascagoula river S of MS 26, 2 mi E. of Benndale, 31° 07'N, 88° 48'W, 28 Mar 1975, *R.D. Thomas, C.M. Allen & G. Landry 42999* (LSJ). **Greene Co.:** roadside in wooded country near McLain on US 98, 31° 07'N, 88° 48'W, 07 Apr 1984, *J.B. Phipps & T.C. Wells 5338* (UWO); roadside in wooded country near McLain on US 98, 07 Apr 1984, *J.B. Phipps & T.C. Wells 5336* (UWO). **Kemper Co.:** 2 mi E. of De Kalb, 12 Aug 1961, *S. McDaniel 2669* (IBE). **Lauderdale Co.:** Meridian; 12 Apr 1900, *C.S. Sargent s.n.* (DOV); 3 mi S of Meridian, 19 Jul 1956, *J.D. Ray, Jr. 7087*; (USF). **Noxubee Co.:** Butler Rd., running N from MS 21 ca. 1 mi W of Gholson, 32° 57'N, 88° 45'W, 27 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8101* (UWO); turn N from Hwy 21 at Gholson onto gravel road beside Church of God of Prophecy, collections along road, 1.5 mi N of Hwy 21, T13NR15E S26, 27 Apr 1984, *T.E. Smith 273* (UWO). **Perry Co.:** damp wooded roadsides on US 98 near New Augusta, 31° 13'N, 89° 00'W, 07 Apr 1984, *J.B. Phipps & T.C. Wells 5342* (UWO). **Simpson Co.:** Saratoga, 01 Apr 1903, *S.M. Tracy 8490* (MSC); SE of Lemon on 35, SR 533A, 32° 07'N, 89° 29'W, 26 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8088* (UWO). **Winston Co.:** ca. 8.0 mi SE of

Louisville on sides of NW-SE gravel rd. ca. 1 mi SE of int. with N-S FAS blacktop, T14N R14E S33 SW4, 08 May 1985, *T.E. Smith 1291* (UWO); ca. 2.5 mi ENE of Handle, side of NE-SW gravel rd. ca. 0.1 mi NE of jct. with NW-SE gravel rd., T13N R14E S14 SE4, 24 Jun 1985, *T.E. Smith 1403* (UWO).

SOUTH CAROLINA. Newberry Co.: 21 Apr 1971, *L.H. Buff, Jr. 203* (USCH).

TEXAS. Jasper Co.: Rich wooded slopes, road to Magnolia Springs, 8 mi S of Jasper, 11 May 1945, *R. McVaugh 6833* (BRIT). **Newton Co.:** Saw Mill Road, N side, 30° 52'N, 93° 50'W, 18 Oct 1988, *J.B. Phipps 6273* (UWO); wooded hills, old pine-oak stand, 4 mi W of Newton, 13 May 1945, *R. McVaugh 6855* (BRIT); wooded hills, old pine-oak stand, 4 mi W of Newton, 13 May 1945, *R. McVaugh 6857* (BRIT).

Crataegus opima Beadle

ALABAMA. Autauga Co.: Hwy 45, 6 mi E of Prattsville, 21 Apr 1962, *T. Denton 81* (ALA). **Butler Co.:** near Greensville, 16 Apr 1931, *E.J. Palmer 38688* (MO). **Cherokee Co.:** Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8043* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8047* (UWO); Little River Canyon Mouth Park, entrance Road, 34° 17'N, 85° 40.5'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8056* (UWO); entrance to Little River Canyon Mouth Park, 34° 17'N, 88° 40.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7930* (UWO); Little River Canyon rim road ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7937* (UWO); entrance road to Little River Canyon Mouth Park, 34° 17'N, 88° 40.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7926* (UWO); Little River Canyon one third way up access road to top, beyond Canyon Mouth Park, 34° 17'N, 85° 41'W, 08 Oct 1998, *J.B. Phipps 7841* (UWO); Little River Canyon one third way up access road to top, beyond Canyon Mouth Park, 34° 17'N, 85° 41'W, 08 Oct 1998, *J.B. Phipps 7840* (UWO). **Geneva Co.:** Bluff on E side of Hwy 45 at crossing of Chectawhatchee River, near Bellwood, 23 Sep 1999, *R. Lance s.n.* (UWO). **Conecuh Co.:** US 31 at Travis Bridge, Sepula R., 17 Aug 1985, *A.R. Diamond 1517* (AUA). **Dallas Co.:** 2 mi NW Shephardsville, SE bank Alabama R., 08 Sep 1982, *S.C. Gunn 1231* (AUA); Elm Bluff, W of Shephardville on Alabama River, 32° 11'N, 87° 05'W, 02 Oct 1998, *J.B. Phipps & R. Lance 7791* (UWO); road to Elm Bluff from Shephardville, ca. 1.5 km W of Shephardville, 32° 11'N, 87° 05'W, 24 Sep 1999, *R.J. O'Kennon & R. Lance 14456* (UWO); road to Elm Bluff from Shephardville, ca. 1.5 km W of Shephardville, 32° 11'N, 87° 05'W, 24 Sep 1999 *R.J. O'Kennon & R. Lance 14457* (UWO); road to Elm Bluff from Shephardville, ca. 1.5 km W of Shephardville, 32° 11'N, 87° 05'W, 24 Sep 1999, *R.J. O'Kennon & R. Lance 14459* (UWO); road to Elm Bluff from Shephardville, ca. 1.5 km W of Shephardville, 32° 11'N, 87° 05'W, 24 Sep 1999, *R.J. O'Kennon & R. Lance 14461* (UWO); road to Elm Bluff from Shephardville, ca. 1.5 km W of Shephardville, 32° 11'N, 87° 05'W, 24 Sep 1999, *R.J. O'Kennon & R. Lance 14460* (UWO); Elm Bluff, W of Shephardville on Alabama River, 32° 11'N, 87° 05'W, 02 Oct 1998, *J.B. Phipps & R. Lance 7792* (UWO); Elm Bluff, W of Shephardville on Alabama River, 32° 11'N, 87° 05'W, 02 Oct 1998, *J.B. Phipps & R. Lance 7793* (UWO); Dallas Co. Rd. 407 between Shephardville and Elm Bluff near parking area on right, along N-W trending track at 1 km, 32° 11'N, 87° 05'W, 14 Apr 1999, *J.B. Phipps 7903* (UWO). **Monroe Co.:** near Frisco City; 01 Jun 1940, *J. Kelly 22* (GA). **Tallapoosa Co.:** Route 50 ca. 1 km E of Martin Dam, 32° 41'N, 85° 53'W, 16 Oct 1984, *J.B. Phipps 5497a* (UWO). **Tuscaloosa Co.:** Tuscaloosa, 11 May 1890, *C. Mohr s.n.* (ALU); Romulus Rd. (Co. Rd. 51) at 3.3 km short of Gainesville Rd, 33° 08'N, 86° 44'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8057* (UWO); Romulus Rd. (Co. Rd. 51) at 3.3 km short of Gainesville Rd., 33° 08'N, 86° 44'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8058* (UWO); Co. Rd. 2, 10 km NE of jct. 10 or 51, SE side of, at gate with big overview opposite, 33° 13'N, 87° 42'W, 13 Apr 1999, *J.B. Phipps 7890* (UWO); Co. Rd. 2, ca. 3 mi S of Coker, E side of road on outside of curve, 33° 13.5'N, 87° 46'W, 13 Apr 1999, *J.B. Phipps 7893* (UWO); Co. Rd. 2, 3 km NE of jct. 10 or 51, SE side of road just before private house, 33° 10'N, 87° 43'W, 13 Apr 1999, *J.B. Phipps 7885* (UWO); Kellytown Rd., 1 km from jct. Valley Rd., 33° 07'N, 87° 49'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8075* (UWO). **Sumter Co.:** ca. 9 mi SSE of York, by Ala 17, 05 Jun 1971, *R. Kral 42979* (VDB).

FLORIDA. Gadsden Co.: Off Dolan Rd. to N, WSW of River Jct., 30 Apr 1983, *R.K. Godfrey 80540* (UWO).

GEORGIA. De Kalb Co.: Decatur, 10 Aug 1901, *R.M. Harper 1184* (MO). **Early Co.:** Kolomoki Mounds State Park, oak woods just W of museum, 31° 28'N, 84° 55'W, 03 Oct 2000, *J.B. Phipps & R. Lance 8196* (UWO); Kolomoki Mounds State Park, oak woods just W of museum, 31° 28'N, 84° 55'W, 03 Oct 2000, *J.B. Phipps & R. Lance 8195* (UWO). **Grady Co.:** Susina Plantation, 11 Apr 1966, *R. White 203* (IBE). **Randolph Co.:** SE of Coleman, 6.7 mi from S end of Co. Rd. 20 and 1.1 mi from jct. with Hwy 160, ca. 20 ft. W of road, in young oak woodland just W of cemetery and telephone cable post "616-12," N31° 39.708', W 84° 54.131', 27 Sep 2001, *R. Lance 2185* (UWO); Co. Rd. 160, just S of Coleman, 31° 39.5'N, 84° 53'W, 03 Oct 2000, *J.B. Phipps & R. Lance 8198* (UWO); SE of Coleman, ca. 0.5 mi W of Co. Rd 160, on N side of Co. Rd. 62, across from old drive, N 31° 28.630', W 84° 52.875', 27 Sep 2001, *R. Lance 2188* (UWO); SE of Coleman, ca. 0.5 mi W of Co. Rd 160, on N side of Co. Rd. 62, across from old drive, N 31° 28.630', W 84° 52.875', 09 Apr 2001, *R. Lance 2109* (UWO).

LOUISIANA. Washington Parish: Thigpel Cr., N of LA 16 and E of Enon, 09 Apr 1978, *R.D. Thomas, D. Moreland & P. Pias 57458* (NLU).

MISSISSIPPI. Clarke Co.: Clarko State Park, wooded slope near exit drive on US Hwy 45, 09 1999, *R. Lance s.n.* (UWO); Clarke County State Park, N exit on US 45, 32° 42'N, 88° 07'W, 12 Apr 1998, *J.B. Phipps 7698;* (UWO). **Lauderdale Co.:** Meridian, 27 Apr 1901, *T.G. Harbison H4200* (US). **Noxubee Co.:** Butler Rd., running N from MS 21 ca. 1 mi W of Gholson, just after first side road left, 32° 57'N, 88° 45'W, 16 Apr 1999, *J.B. Phipps 7915* (UWO); Butler Rd. running N from MS 21 ca. 1 mi W of Gholson, E side of road, 32° 57'N, 88° 45'W, 27 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8102* (UWO); Butler Rd., running N from MS 21 ca. 1 mi W of Gholson, E side of road, 32° 57'N, 88° 45'W, 27 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8096* (UWO); Butler Rd., running N from MS 21 ca. 1 mi W of Gholson, E side of road, 32° 57'N, 88° 45'W, 27 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8099* (UWO); Butler Rd., running N from MS 21 ca. 1 mi W of Gholson, E side of road, 32° 57'N, 88° 45'W, 27 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8098* (UWO); Butler Rd., running N from MS 21 ca. 1 mi W of Gholson, just after first side road left, at right, 32° 57'N, 88° 45'W, 16 Apr 1999, *J.B. Phipps 7916* (UWO). **Perry Co.:** ca. 11 mi NE of Wiggins, NW of jct. of forest road 318B-1 and Black Creek Trail, along Black Creek Trail, "Red Hills", T1S, R10W, section 28 and 21, 30 Apr 19??, *R.F.C. Naczi et al 5119* (VDB). **Smith Co.:** SE of Lemon on 35, SR 533A, 32° 07'N, 89° 29'W, 26 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8089* (UWO). **Winston Co.:** ca. 12 mi ESE of Louisville N side of SE-SW gravel rd. ca. 1 mi NW of Hwy 490 int., T14N R14E S23 SE4, 08 May 1985, *T.E. Smith 1289* (UWO).

TEXAS. Jasper Co.: S of Jasper, 15 Apr 1942, *C.L. & A.A. Lundell 11191* (SMU); S of Jasper off highway 96 between road to Magnolia Springs and road to Roganville, E side of road, 14 Apr 1963, *D.S. and H.B. Correll 27231* (LL); Road to Magnolia Springs, 8 mi S of Jasper, 11 May 1945, *R. McVaugh 6833* (SMU); S of Jasper; 09 Sep 1942, *C.L. Lundell & S.W. Geiser 111819* (SMU). **Newton Co.:** Newton, 04 Jul 1960, *J. Knapp s.n.* (NATC); Saw Mill Road ca. 1.5 km W of Saw Mill Town, 30° 52'N, 93° 50'W, 12 Apr 1988, *J.B. Phipps & L. Lowrie 6079* (UWO); Saw Mill Road ca. 1.5 km W of Saw Mill Town, 30° 52'N, 93° 50'W, 12 Apr 1988, *J.B. Phipps & L. Lowrie 6077* (UWO); Saw Mill Road, N side, 30° 52'N 93° 50'W; 18 Oct 1988, *J.B. Phipps 6274* (UWO); Saw Mill Road, N side, 30° 52'N, 93° 50'W; 18 Oct 1988, *J.B. Phipps 6275* (UWO); Saw Mill Rd. ca. 0.75 km W of Saw Mill Town, 30° 52'N, 93° 49'W, early Nov 1987, *L. Lowrie s.n.* (UWO); intersection of two dirt roads S of US 190, the one joining US 190 3 mi W of Newton, 30° 52'N, 93° 51'W, 12 Apr 1988, *J.B. Phipps & L. Lowrie 6076* (UWO); Saw Mill Road, N side, 30° 52'N, 93° 50'W, 18 Oct 1988, *J.B. Phipps 6272* (UWO); Saw Mill Road, N side, 30° 52'N, 93° 50'W, 18 Oct 1988, *J.B. Phipps 6276* (UWO); 4 mi W of Newton, 13 May 1945, *R. McVaugh 6856* (SMU).

Crataegus cf. **opima** Beadle

ALABAMA. Cherokee Co.: Entrance road to Little River Canyon Mouth Park, 34° 17'N, 88° 40.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7945* (UWO); entrance road to Little River Canyon Mouth Park, 34° 17'N, 88° 40.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7927* (UWO); Little River Canyon, S rim above Canyon Mountain Park, between mi 2 and 3 at county road bordering canyon rim, 07 Apr 1998, *R. Lance s.n.* (UWO). **Dallas Co.:** r oad to Elm Bluff from Shephardville, ca. 1.5 km W of Shephardville a ong trail to deer pit (N of road), 32° 11'N, 87° 05'W, 24 Sep 1999, *R.J. O'Kennon & R. Lance 14463* (UWO); N of Trussville on road to Clay, 1.9 km. after bridge over Highway I-59. RHS before 45 mph sign, 33° 40'N, 86° 36'W, 25 Apr 1983, *P.F. Ulf-Hansen PF029* (UWO). **Tuscaloosa Co.:** Co. Rd. 2, 5 km NE of jct. 10 or 51, 33° 12'N, 87° 43'W, 13 Apr 1999, *J.B. Phipps 7887* (UWO); probably Co. Rd. 19 (but maybe Co. Rd. 51), 4 km SE of jct. 2, 33° 07'N, 87° 44'W, 13 Apr 1999, *J.B. Phipps 7883* (UWO); Co. Rd. 2 at 11 km NE of jct. 51 at overlook, 33° 13'N, 87° 42'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8069* (UWO).

MISSISSIPPI. Noxubee Co.: Butler Rd., running N from MS 21 ca. 1 mi W of Gholson, E side of road, 32° 57'N, 88° 45'W, 28 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8103* (UWO).

Crataegus pallens Beadle (placed with *C. venusta* in text)

ALABAMA. Cherokee Co.: Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7943* (UWO). **Dallas Co.:** Dallas Co. Rd. 407 between Shephardville and Elm Bluff near parking area on right, along NW trending track at 1 km, 32° 11'N, 87° 05'W, 14 Apr 1999, *J.B. Phipps 7902* (UWO). **Tuscaloosa Co.:** banks of Warrior R., 1895, *C. Mohr s.n.* (ALA).

NORTH CAROLINA. Buncombe Co.: Biltmore, 18 Sep 1902, *Biltmore Herb. s.n.* (DOV).

Crataegus pinetorum Beadle

ALABAMA. De Kalb Co.: De Soto State Park, 25 Sep 2001, *R. Lance 2174* (UWO). **Jefferson Co.:** near Birmingham, 20 Apr 1900, *C.S. Sargent s.n.* (DOV).

GEORGIA. Floyd Co.: Horseleg Mtn., 07 Oct 1982, *J.B. Phipps 5169* (UWO). **Jackson Co.:** Tallahassee Shoals, 30 Apr 1930, *J.M. Reade E8293* (GA).

MISSISSIPPI. Smith Co.: SE of Lemon, 30 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8092* (UWO); SE of Lemon, 12 Apr 2000, *J.B. Phipps 8122, 8123* (UWO).

Crataegus pulcherrima Ashe

ALABAMA. Butler Co.: Oaky Streak, approx. 1.5 mi W of Co. 59, 04 Apr 1985, *A.R. Diamond 276* (AUA). **Cherokee Co.:**

Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N 85° 42'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8044* (UWO). **Choctaw Co.:** 9 mi N of Toxey , just N firetower, Tallahatta formation, 03 May 1968, *S. McDaniel 10600* (FSU, IBE). **Pike Co.:** Sandy 'Big Pocosin', SE Troy and NE Fairgrounds, 10 Sep 1968, *R. Kral 33159* (MO).

FLORIDA. Gadsden Co.: Quincy, in woods, 04 Sep 1895, *G.V. Nash 2568* (DOV, MSC); River Jct., 10-11 Aug 1895, *G.V. Nash 2377* (DOV); W of property belonging to River Jct. Hunt Club, beyond end of road on right fork off Dolan Road, W, SW of River Jct., 22 May 1982, *R.K. Godfrey 79819* (UWO); SW of railroad/Mosquito Creek, WSW of River Jct., 22 May 1982, *R.K. Godfrey 79815* (UWO). **Holmes Co.:** Route 185, ca. 1.25 km SW of Co. Rd. 181 just (ca. 150 m) NE of brow on SE Side of road, 30° 52'N, 86° 02'W, 14 Aug 1993, *J.B. Phipps 6741* (UWO). **Jackson Co.:** 9 mi NW of Marianna, 21 Oct 1955, *R.K. Godfrey & H. Kurz 54277* (DUKE). **Leon Co.:** Tallahassee, ca. 2 mi S of town, 10 Apr 1966, *R.A. Norris 705* (IBE); woods near Lake Jackson, 07 Apr 1934, *L. Griscom 21519* (GH). **Liberty Co.:** near Bristol, 06 Sep 1940, *W.A. Murrill* s.n. (GA); near picnic area, Torreya State Park, 16 Jul 1983, *R.K. Godfrey 80782* (UWO). **Wakulla Co.:** near Wakulla Springs, 10 Jun 1958, *R.K. Godfrey 57030* (DUKE).

GEORGIA. Randolph Co.: Co. Rd. 62, 1 3/8 mi from jct. 160, top of bank on LHS, 31° 38'N, 84° 54'W, 03 Oct 2000, *J.B. Phipps & R. Lance 8202* (UWO); Co. Rd. 62, 1 1/8 mi from jct. 160 top of road bank on RHS, 31°38.5'N, 84° 53.5'W, 03 Oct 2000, *J.B. Phipps & R. Lance 8201* (UWO); Co. Rd. 62, 7/8 mi from jct. 160 top of road bank on RHS, 31° 38'N, 84° 53'W, 03 Oct 2000, *J.B. Phipps & R. Lance 8200* (UWO); SE of Coleman, 6.2 mi from S end of Rd. 20 and 1.6 mi from jct. with Hwy 160, on E side of road, N 31° 39.468', W 84° 54.642', 27 Sep 2001, *R. Lance 2184* (UWO); SE of Coleman, ca. 0.5 mi W of Co. Rd. 160, on N side of Co. Rd. 62, across from old drive, N31° 28.630', W 84° 52.875', 27 Sep 2001, *R. Lance 2189* (JWO). **Worth Co.:** Flint River, 1.9 mi W of Warwick, 17 Aug 1966, *W.R. Faircloth 3901* (GA).

LOUISIANA. Washington Parish: Bogalusa, 05 Apr 1919, *R.S. Cocks 3149* (NO).

MISSISSIPPI. George Co.: W bank of Pascagoula R. 7 mi E of Bendale, 28 Mar 1975, *R.D. Thomas, C.M. Allen & G. Landry 42999* (NLU). **Lauderdale Co.:** Mt. Barton and vicinity of S of Meridian, 11 Jun 1957, *G.R. Cooley 5274* (USF). **Smith Co.:** SE of Lemon on 35. SR 533A, 32° 07'N, 89° 29'W, 26 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8091* (UWO); ESE of Lemon on 533A, right hand side of road at 1.1 km W of jct. 533, 32° 07'N, 89° 26'W, 26 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8095* (UWO); SE of Lemon on 35, SR 355A, 32° 07'N, 89° 28'W, 26 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8093* (UWO).

Crataegus sargentii Beadle

ALABAMA. Cherokee Co.: Little River Canyon Mouth Park, entrance road, 34° 17'N, 85° 40.5'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8052* (UWO); Little River Canyon, road from canyon mouth to Daniel's Gap, middle third, 34° 17'N, 85° 41'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7932* (UWO); Little River Canyon rimroad ca. 1 km direct NW from Daniel's Gap, 34° 18'N, 85° 42'W, 22 Sep 1999, *J.B. Phipps & R. J. O'Kennon 8041* (UWO). **Clarke Co.:** Co. Rd. 15, S of Jackson, 31° 26'N, 87° 52'W, 01 Oct 2000, *J.B. Phipps & R. Lance 8194* (UWO). **Dale Co.:** 3 mi N of Clayhatchee, by AL 85, 09 Jun 1971, *R. Kral 43182* (AUA). **Dallas Co.:** ca. 5 mi E of Sardis on Co. Rd. 30, 32° 15'N, 86° 48'W, 06 Apr 1984, *J.B. Phipps & T.C. Wells 5321* (UWO). **De Kalb Co.:** De Soto State Park, to rear of campsite #27, 34° 30.019'N, 85° 37.579'W, 25 Sep 2001, *R. Lance 2171* (UWO); De Soto State Park, near campground, 34° 30'N, 85° 38'W, 08 Oct 1998, *J.B. Phipps 7846* (UWO); Lookout Mountain, De Soto State Park, SE side of campground, near site # 59, 16 Sep 1994, *R. Lance 9405* (UWO); Lookout Mountain, De Soto State Park, NW side of campground, near site #21, 16 Sep 1994, *R. Lance 9402* (UWO); De Soto State Park, campground area, 34° 30"N, 85° 38'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8035* (UWO); scrubby woodland on conglomerate ca. 5 km NW of Little R. on route 35, 34° 24'N, 85° 39'W; 08 Oct 1982, *J.B. Phipps 5190* (UWO), De Soto State Park, woodland adjacent to campground, 34° 30.019'N, 85° 37.579'W, 25 Sep 2001, *R. Lance 2169* (UWO); De Soto State Park, campground area, 34° 30'N, 85° 38'W, 19 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7953* (UWO); Lookout Mountain, back roads S of Mentone on route 117, 34° 33"N, 85° 35'W, 08 Oct 1982, *J.B. Phipps 5196* (UWO). **Marshall Co.:** Lake Guntersville State Park, Cutchenmire Trail, 34° 22'N, 86° 11'W, 21 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8029* (UWO). **St. Clair Co.:** near Springville on U.S. 11, 3.5 km from jct. with Old Springville Rd. RHS going N, 50 m. from field edge, along fenceline, 33° 46'N, 86° 29'W, 26 Apr 1983, *P.F. Ulf-Hansen PF037* (UWO). **Tuscaloosa Co.:** Lock 13, 23 May 1952, *R.L. and O.D. Chermock s.n.* (ALA); Kellytown Rd, 1 km from jct. Valley Rd., 33° 07'N, 87° 49W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8074* (UWO); Co. Rd. 2, 5 km NE of jct. 10 or 51, 33° 12'N, 87° 43'W, 13 Apr 1999, *J.B. Phipps 7888* (UWO); Co. Rd. 2 at 11 km NE of jct. 51 at overlook, 33° 13'N, 87° 42'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8067* (UWO); Romulus Rd. (Co. Rd. 51) at 3.3 km short of Gainesv lle Rd, 33° 08'N, 86° 44'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8064* (UWO).

FLORIDA. Holmes Co.: Rte. 185, 1.9 km SW of Co. Rd 181, NW side of road, backing onto woodland, 30° 53'N, 86° 05'W, Apr 1991, *J.B. Phipps 6477* (UWO). **Leon Co.:** Border of second-growth upland wood and, by Hartsfield Road, N side, perhaps the equivalent of a city block off capital circle, Tallahassee, 06 Apr 1983, *R.K. Godfrey 80414* (UWO).

GEORGIA. Burke Co.: Rte. 56, N of intersection with 80, just N of Lake Crystal Rd. to E, 33° 05'N, 82° 03'W, 09

Apr 1991, *J.B. Phipps 6500*; (UWO). **Floyd Co.:** Horseleg Mtn., 34° 14'N, 85° 13'W, 07 Oct 1982, *J.B. Phipps 5171* (UWO). McGee Bend Rd. off Ga. 100 (WSW of Rome), 34° 10.5'N, 85° 22.5'W, 04 Apr 2000, *J.B. Phipps 8211* (UWO). Horseleg Mtn., near roadside, S-side, 34° 14'N, 85° 13'W, 07 Oct 1982, *J.B. Phipps 5173* (UWO). McGee Bend Rd. off GA 100 (WSW of Rome), 34° 10.5'N, 85° 22.5'W, 04 Oct 2000, *J.B. Phipps 8210* (UWO). **Grady Co.:** Upland second growth woodland, 3 mi NW of Beachton, by Ga. Rt. 93, 31 Mar 1982, *R.K. Godfrey 79490* (UWO).

MISSISSIPPI. Jasper Co.: 6 mi N of Montrose, 14 Apr 1962, *S. McDaniel 2943* (IBE). **Noxubee Co.:** Butler Rd., running N from MS 21, ca. 1 mi W of Gholson, before first side road left, 32° 57"N, 88° 45'W, 16 Apr 1999, *J.B. Phipps 7914* (UWO). **Smith Co.:** SE of Lemon on SR 35 to SR 533 at 0.8 km W of bridge, 32° 07'N, 89° 27'W; 26 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8094* (UWO).

Crataegus tecta Beadle

ALABAMA. Cherokee Co.: Little River Canyon road, ascent from canyon mouth to Daniel's Gap, ca. halfway up, 34° 17'N, 85° 41'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8051* (UWO). Little River Canyon, road from canyon mouth to Daniel's Gap, third of way up, 34° 17'N, 85° 41'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7931* (UWO). Little River Canyon rimroad, ca. 0.6 km N of Daniel's Gap, at overlook, 34° 18'N, 85° 41.5'W, 19 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7948* (UWO); Little River Canyon rimroad, ca. 1 mi NW of Daniel's Gap, 34° 17'N, 85° 41'W, 08 Oct 1998, *J.B. Phipps 7844a* (UWO). **Dallas Co.:** Elm Bluff, W of Shephardville on Alabama River, wooded slope on N side of access road ca. 2 mi back, 32° 11'N, 87° 05'W, 02 Oct 1998, *J.B. Phipps & R. Lance 7789* (UWO). **Geneva Co.:** Bluff on W side of Hwy 167, near High Bluff and just S of crossing of Chectawhatchee River, 23 Sep 1999, *R. Lance s.n.* (UWO). **Houston Co.:** Philadelphia, 22 Jun 1984, *R.D. Whetstone 14183* (UWO). **Montgomery Co.:** US 80 at Caney Creek, thickets at N side of highway, 32° 19'N, 86° 23'W, 24 Sep 1999, *R.J. O'Kennon & R. Lance 14451* (UWO). **Sumter Co.:** 3 mi SW York, 07 Jun 1963, *S.B. Jones, Jr. 1319* (GA). Old Bluffport, off S.R. 28 ca. 7 mi due E of Livingston, along wooded tracks ca. 3/4 mi back from Tombigbee R, 32° 42'N, 88° 07'W, 11 Apr 1998, *J.B. Phipps 7695* (UWO). **Tuscaloosa Co.:** 4.9 mi S of Shirley Bridge (Sipsey) on Co. Rd. 21, 07 Apr 1977, *J.H. Wiersema 48* (ALU). 4.9 mi E of Shirley Bridge on Co. Rd. 21, 07 Apr 1970, *J.A. Daniels 22* (ALU); Co. Rd. 2 at 11 km NE of jct. 51 at overlook, 33° 13'N 87° 42'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8066* (UWO); Jct. Kellytown Rd. and Valley Rd., 33° 08'N, 87° 48'W, 23 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8072* (UWO).

FLORIDA. Gadsden Co.: Turkey Flight Park, Chattahoochee, near parking area, 21 Sep 1999, *R. Lance s.n.* (UWO). **Jackson Co.:** Three Rivers Recr. Area, 01 Apr 1982, *D.S. & H.B. Correll 53541* (USF). **Leon Co.:** 4 mi E of Tallahassee, deciduous woods, 16 Mar 1955, *R. K. Godfrey 53022* (USF); 2 mi N of Tallahassee, 31 Mar 1958, *R.K. Godfrey 56323* (NCSC).

GEORGIA. Bartow Co.: US 41 at Pumpkinvine Cr., small flood-plain, 34° 05'N, 87° 44.5'W, 19 Apr 2000, *J.B. Phipps et al. 8167* (UWO). **Clarke Co.:** 0.5 mi S of Athens, 26 Apr 1940, *W.H. Duncan 2073* (GA). **Decatur Co.:** Borders of woodland, between swimming area and Chattahoochee Park, U.S. Corps of Engineers property, close to Lake Seminole, ca. 3 mi N of Chattahoochee, Fla., 28 May 1983, *R.K. Godfrey and A. Gholson 80660* (UWO). **Early Co.:** Kolomoki Mounds St. Park woods behind museum, 20 Sep 1999, *R. Lance s.n.* (UWO); Kolomoki Mounds St. Park woods behind museum, 20 Sep 1999, *R. Lance s.n.* (UWO). **Floyd Co.:** McGee Bend Rd., off Ga. 100 (WSW of Rome), 34° 10.5'N, 85° 22.5'W, 19 Apr 2000, *J.B. Phipps et al. 8159* (UWO). **Randolph Co.:** SE of Coleman, ca. 0.5 mi W of Co. Rd 160, on N side of Co. Rd. 62, across from old drive, N 31° 28.630', W 84° 52.875', 27 Sep 2001, *R. Lance 2191* (UWO); SE of Coleman, ca. 0.5 mi W of Co. Rd 160, on N side of Co. Rd. 62, across from old drive, N 31° 28.630', W 84° 52.875', 27 Sep 2001, *R. Lance 2190* (UWO); SE of Coleman, ca. 0.5 mi W of jct. with Hwy 160, on S side of road, at woods and field corner, near phone box "616-6," N 31° 39.898', W 84° 53.642', 27 Sep 2001, *R. Lance 2186* (UWO); SE of Coleman, ca. 1.2 mi W of Co. Rd 160, on E side of Co. Rd. 62, on bank above road, after creek crossing, near pasture on hill, 27 Sep 2001, *R. Lance 2113* (UWO); SE of Coleman, ca. 0.5 mi W of Co. Rd 160, on N side of Co. Rd. 62, across from old drive, N 31° 28.630', W 84° 52.875', 09 Apr 2001, *R. Lance 2110* (UWO); SE of Coleman, ca. 0.1 mi E of Co. Rd 20, on hilltop road into young pine plantation, N 31° 38.795', W 84° 55.069', 27 Sep 2001, *R. Lance 2181* (UWO).

MISSISSIPPI. Lauderdale Co.: Meridian, 15 Apr 1902, *T.G. Harbison s.n.* (NCU).

Marion Co.: Pearl River at White Bluff NW of Morgantown, 17 May 1967, *S.B. Jones 1236* (NCU). **Newton Co.:** ca. 2 mi S of Chunky, Chunky Sand Hill, 32° 18'N, 88° 55'W, 25 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8085* (UWO). **Noxubee Co.:** Butler Rd., running N from MS 21 ca. 1 mi W of Gholson, E side of road, 32° 57'N, 88° 45'W, 27 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8097* (UWO). Butler Rd., running N from MS 21 ca. 1 mi W of Gholson, E side of road, 32° 57'N, 88° 45'W, 27 Sep 1999, *J.B. Phipps, R.J. O'Kennon & R. Lance 8100* (UWO), Butler Rd., running N from MS 21 abt 1 mi W of Gholson, just after first side road left, at right, bank, 32° 57'N, 88° 45'W, 16 Apr 1999, *J.B. Phipps 7917* (UWO). **Pearl River Co.:** Off route 43 ca. 12 km S of crossroads (at route 26), 30° 40'N, 89° 45'W, 08 Apr 1984, *J.B. Phipps & T.C. Wells 5346* (UWO).

NORTH CAROLINA. Buncombe Co.: Biltmore, 09 May 1902, *C.D. Beadle s.n.* (DOV).

TENNESSEE. Grundy Co.: NE of Tracy City on mine road from Hobbs Hill to coalmine, 35° 17'N, 85° 34'W, 01 Sep 1983, *P.F. Ulf-Hansen PF112* (UWO).

Crataegus venusta Beadle

ALABAMA. Bibb Co.: Co. Rd. 33, at Cahaba River, 14 Apr 1977, *A. Sessler 954* (AUA). **Butler Co.:** Greenville, - Aug 1898, *C. Mohr s.n.* (ALU). **Cherokee Co.:** Entrance Road to Little River Canyon Mouth Park, 34° 17''N, 88° 40.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7929* (UWO); Little River Canyon rimroad just NE of Daniel's Gap, 34° 17'N, 85° 41.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7935* (UWO); Little River Canyon rimroad just N of Daniel's Gap, 34° 17'N, 85° 41.5'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8049* (UWO); Little River Canyon rimroad just NE of Daniel's Gap, 34° 1'N, 85° 41.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7934* (UWO); entrance Road to Little River Canyon Mouth Park, 34° 17'N, 88° 40.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7925* (UWO), Little River Canyon rimroad just NE of Daniel's Gap, 34° 17'N, 85° 41.5'W, 18 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7936* (UWO); Little River Canyon rimroad, across canyon of Falls Creek from '*Pulcherrimae* site', NW side of road on fairly straight stretch with broad shoulder right, 34° 18.5'N, 85° 41.5'W, 19 Apr 1999, *J.B. Phipps & R.J. O'Kennon 7949* (UWO); Little River Canyon road, ascent from canyon mouth to Daniel's Gap, ca. halfway up, 34° 17'N, 85° 41'W; 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8050* (UWO); Little River Canyon Mouth Park, entrance road, 34° 17'N, 88° 40.5'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8053* (UWO). **Dallas Co.:** Dallas Co. Rd. 407 between Shepnardville and Elm Bluff near parking area on right, along N-W trending track at 1 km, 32° 11'N, 87° 05'W, 14 Apr 1999, *J.B. Phipps 7901* (UWO). **Marshall Co.:** Lake Guntersville State Park on Cutchenmire Trail near Berry Point, 34° 22'N, 86° 11'W, 21 Apr 1999, *J.B. Phipps, R.J. O'Kennon & D. Spalding 7966* (UWO); AL 219, 4 km S of jct. AL 83 in Talladega National Forest, hedgerow on E side opposite two minor roads, 37° 43'N, 87° 06.5'W, 13 Apr 1999, *J.B. Phipps 7882* (UWO). **Pickens Co.:** dirt road between Fellowship and New Hope churches, 2.2 mi N of Co. Rd. 30, 09 Apr 1977, *L.J. Davenport 22* (ALA). **St. Clair Co.:** ca. 9 mi N Pell City, 22 Apr 1968, *R. Kral 30389* (VDB). **Tallapoosa Co.:** Route 50 ca. 1 km E of Martin Dam, 32° 41'N, 85° 53'W, 16 Oct 1984, *J.B. Phipps 5501* (UWO). **Tuscaloosa Co.:** 4.9 mi S of Shirley Bridge and Co. Rd. 21, 07 Apr 1977, *J.H. Wiersema 48* (ALA); Co. Rd. 2, 10 km NE of jct. 10 or 51, SE side of, at gate with big overview opposite, 33° 13'N, 87° 42'W, 13 Apr 1999, *J.B. Phipps 7891* (UWO).

FLORIDA. Jefferson Co.: By U.S. Rt. 27, 1 mi SE of Jefferson-Leon Co. line and NW of Wacissa-Lloyd Cross-road, 27 Mar 1982, *R.K. Godfrey 79486* (UWO).

GEORGIA. Randolph Co.: SE of Coleman, ca. 0.5 mi W of Co. Rd. 160, on N side of Co. Rd. 62, across from old drive, N 31° 28.630', W 84° 52.875', 27 Sep 2001, *R. Lance 2192* (UWO); SE of Coleman, ca. 0.5 mi W of Co. Rd. 160, on N side of Co. Rd. 62, across from old drive, N 31° 28.630', W 84° 52.875', 09 Apr 2001, *R. Lance 2108* (UWO), SE of Coleman, ca. 0.1 mi E of Co. Rd. 20, on hilltop road into young pine plantation, N 31° 38.795', W 84° 55.069', 10 Apr 2001, *R. Lance 2115* (UWO); SE of Coleman, ca. 6.2 mi from S end of Rd. 20 and 1.6 mi from jct. with Hwy 160, N 31° 39.468', W 84° 54.642', 10 Apr 2001, *R. Lance 2118* (UWO).

LOUSIANA. Bienville Parish: Bear Creek Gas Field in T16N, R6W, Sec. 1 approx. 4 mi SE of Bryceland, 12 Apr 1975, *D. Moreland 576* (UWO).

MISSISSIPPI. Jasper Co.: 6 mi N of Montrose, 20 Aug 1961, *S. McDaniel 2683* (IBE). **Lauderdale Co.:** ca. 2.5 mi S of Meridian (T15N R16E S6 NE 4) off side of NW-SE gravel rd., 18 May 1985, *T.E. Smith et al. 1327* (UWO). **Kemper Co.:** Few mi along paved road W from MS 39 to Sciple's Mill turn-off, 32° 52'N, 88° 44'W, 16 Apr 1999, *J.B. Phipps 7913* (UWO). **Noxubee Co.:** MS 21, S side, 6.45 km W of jct. 39, 32° 58'N 88° 40'W, 16 Apr 1999, *J.B. Phipps 7918* (UWO).

TEXAS. Newton Co.: ca. 20 mi NW of Burkville on Little Cow Creek, 11 May 1956, *E. Whitehouse 31248* (SMU). **Jasper Co.:** 7.5 mi N of Jasper, 11 May 1945, *R. McVaugh 6828* (SMU).

Crataegus ser. **Pulcherrimae** (Beadle ex E.J. Palmer) Robertson, not assigned to species

ALABAMA. Cherokee Co.: Little River Canyon Mouth Park, entrance road, 34° 17'N, 85° 40.5'W, 22 Sep 1999, *J.B. Phipps & R.J. O'Kennon 8054* (UWO). **Dallas Co.:** 9 km E of Sardis on Co. Rd. 30, 32° 15'N, 86° 48'W, 15 Oct 1984, *J.B. Phipps 5485* (UWO). **De Kalb Co.:** Little River Canyon rimroad, ca. 1 mi NW of Daniel's Gap, 34° 17'N, 85° 41'W, 08 Oct 1998, *J.B. Phipps 7844b* (UWO). **Sumter Co.:** Old Bluffport, off S.R. 28 ca. 7 mi due E of Livingston, along wooded tracks ca. 3/4 mi back from Tombigbee R., 32° 42'N, 88° 07'W, 11 Apr 1998, *J.B. Phipps 7697* (UWO). **Tuscaloosa Co.:** Tuscaloosa, 15 May 1874, *R.A. Smith s.n.* (ALU); along Co. Rd. 2, nilltop S of Romulus, wooded slope on E side, 10 Apr 1999, *R. Lance s.n.* (UWO).

FLORIDA. Gadsden Co.: Turkey Flight Park, Chattahoochee, 21 Sep 1999, *R. Lance s.n.* (UWO). **Leon Co.:** woods near L. Jackson, 04 Apr 1934, *L. Griscom 21519* (GH).

GEORGIA. Early Co.: Kolomoki Mounds State Park, ca. 0.25 mi NE of Tall Pines campground on ridge in mixed hardwood forest, 27 Sep 2001, *R. Lance 2178* (UWO). **Randolph Co.:** Co. Rd. 160, just S of Coleman, 31°

39.5'N, 84° 53'W, 03 Oct 2000, *J.B. Phipps & R. Lance 8197* (UWO); SE of Coleman, ca. 0.5 mi W of Co. Rd. 160, on N side of Co. Rd. 62, across from old drive, N 31° 28.630', W 84° 52.875', 27 Sep 2001, *R. Lance 2193* (UWO).

LOUISIANA. Washington Parish: woods beside Silver Creek and La. 438 N of Mt. Hermon, Sec. 41, T1S, R9E, 31 Oct 1980, *R.D. Thomas et al 74575* (UWO).

MISSISSIPPI. Greene Co.: roadside in wooded country near McLain on US 98, 31° 07'N, 88° 48'W, 07 Apr 1984, *J.B. Phipps & T.C. Wells 5334* (UWO).

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Book Reviews

Tammi Ruth Hartung. 2000. **Growing 101 Herbs That Heal: Gardening Techniques, Recipes, and Remedies.** (ISBN 1-58017-215-6, pbk.). Storey Books, Schoolhouse Road, Pownal, VT, 05261, U.S.A. (**Orders:** www.storeybooks.com). $24.95, 250 pp., color photographs, color illustrations, 8 1/4" × 10".

With advice for amateur gardeners and for those interested in a starting a medicinal plant farm, this is an enjoyable and useful guide to growing and using medicinal plants. As stated in the title, 101 medicinal plants are covered, including favorites such as Saint John's Wort (*Hypericum perforatum*), Echinacea (*Echinacea* sp.), and licorice (*Glycyrrhiza glabra*). Lesser known medicinal plants are also included, such as pleurisy root (*Asclepias tuberosa*). The author is an expert in the uses and cultivation of medicinal plants and is a certified medical herbalist and organic grower. The practical advice in this book is colored by her experiences running the Desert Canyon Farm & Learning Center in Colorado with her husband. The latter part of the book is dedicated to detailed descriptions of the medicinal plants and is illustrated with color photographs. Earlier chapters include useful advice on organic gardening with tips on garden pest control, starting seeds, year-round garden maintenance, and composting. An excellent section covers plant selection and garden design. In addition, there are chapters dedicated to recipes, as well as instructions on making herbal medicines.—*Marissa Oppel, MS, Collections Research Assistant, Botanical Research Institute of Texas, Fort Worth, Texas 76102-4060, U.S.A.*

Johannes Seidemann. 2005. **World Spice Plants: Economic Usage, Botany, Taxonomy**. (ISBN 3-540-22279-0, hbk.). Springer-Verlag, Berlin, Germany. (**Orders:** www.springeronline.com). $149.00, 592 pp., 93 color photographs, 9 1/2" × 10 1/2".

This encyclopedic guidebook covers over 1,400 spice plants from the world over, including economically important spice plants and aromatic plants. The lay-out of the book is simple and easy-to-use. The spice plant entries are in order alphabetically by scientific name. Each entry includes information on botanical nomenclature, such as family names, species, varieties, subspecies, authorities, synonyms, and common names in multiple languages, including Russian, English, Spanish, Chinese, Arabic, and Japanese, to name a few. Information on uses, such as flavoring, essential oil, condiment, and curry ingredient are included, as well as the part(s) of the plant that is used. Information on geographical distribution, including the locations where the plant is cultivated is also included. The extensive reference section is one of the more useful features. It is a real time saver for those who don't want to wade through oceans of scientific articles and databases. The references include both primary and secondary scientific literature. The authors also include instructive color photographs of many of the plants growing in the field and in the form in which they are used, such as dried seeds. The helpful indices include an index of common names and an index of illustrations. Overall, this is an instructive and useful reference book for school libraries and food science laboratories.—*Marissa Oppel, MS, Collections and Research Assistant, Botanical Research Institute of Texas, Fort Worth, Texas 76102-4060, U.S.A.*

CRATAEGUS SERIES *BRACTEATAE* AND *TRIFLORAE* (ROSACEAE)

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ABSTRACT

Crataegus series *Bracteatae* and *Triflorae*, both of the southeastern United States, are revised and shown to possess significant similarities. In each series, one of the two species recognized is moderately common, the other possibly extinct in the wild, raising conservation concerns. A key to series is provided and full descriptions for both series. Each series has a key to species, detailed species descriptions, and county level distribution maps for each species, these being the first such known to be produced. In addition, each species except *C. harbisonii* (ser. *Bracteatae*), which has an excellent illustration in Lance and Phipps (2000), is provided a with new line illustration. All species are typified and representative specimens are cited for each.

KEY WORDS: *Crataegus*, ser. *Bracteatae*, ser. *Triflorae*, taxonomic revision, typification, illustrations, maps, keys, specimen citation

RESUMEN

Crataegus series *Bracteatae* y *Triflorae*, ambas del sudeste de los Estados Unidos, se revisaron y mostraron tener similitudes significativas. En cada serie, una de las dos especies reconocidas es relativamente común, la otra posiblemente extinta en la naturaleza y presentando problemas de conservación. Se ofrece una clave para las series y una descripción completa de ambas. Cada una de las series tiene una clave de especies, descripciones detalladas de las especies, y mapas de distribución a nivel de condado de todas las especies, siendo la primera vez que se produce esto. Además, se aporta una ilustración todas las especies excepto *C. harbisonii* (ser. *Bracteatae*), que tiene una ilustración excelente en Lance y Phipps (2000). Se tipifican todas las especies y se citan especimenes representativos de cada una de ellas.

This paper constitutes another contribution to the continuing series by the first author aimed at revising much of *Crataegus* for the southeastern United States. Other numbers have dealt with ser. *Aestivales* (Phipps 1988), series *Apiifoliae*, *Cordatae*, *Microcarpae* and *Brachyacanthae* (Phipps 1998), *Parvifoliae* (Phipps & Dvorsky 2006) and *Pulcherrimae* (Phipps et al. 2006).

This paper is primarily a revision of the species in ser. *Bracteatae* and *Triflorae* but the series are brought together for convenience and because they do share certain diagnostic characteristics. Appropriate molecular analysis will answer questions about serial relationships. An abbreviated key to series that occur in the southeastern United States (see taxonomic part) illustrates their diagnostic characteristics and separates the two series from the others in that region. It is possible that the two series should be fused but it is not the intention of this paper to develop that issue. Interestingly though, L. Echols, RL and JBP have recently encountered a population in Houston Co., Georgia that appears to share characteristics between *C. triflora* and *C. ashei* although on the small sample available judgement is withheld.

Series *Triflorae* and *Bracteatae* are both marked by a high degree of glandularity, considerable pubescence, unlobed to only very shallowly lobed leaves, few-flowered inflorescences, calyx lobe margins dissected and large flowers (20–30 mm diameter). *Crataegus triflora* has an unusually high stamen number relative to other members of the genus. Inflorescences borne on the new season's growth arising direct from woody extension shoots may occur in all species except *C. ashei* and are another attribute of both series. A separate discussion of this last point follows below. Elsewhere, this feature has only been recorded in *Mespilus canescens* among closely related taxa. All species are bushes or occasionally small trees that are found in open woodland and woodland margin often on black-soil prairies. Each series has two species, one moderately common, the other very rare or extinct.

Crataegus generally bears its reproductive organs terminally on woody short shoots. Although internode length varies somewhat in these sort shoots, it is shorter to much shorter than on extension shoots. Moreover, such short shoots are perennial, borne lateral to extension shoots, are woody and do not themselves branch.

The approach used in this paper is essentially the same as that used in others of the set. Loans were requested from nearly 40 southeastern herbaria plus three of national scope: HUH, MO and US, but material of the two series turned up in only 22 loans. The loan material was supplemented by extensive collecting over a number of years mainly by JBP and RL. Four phenetic species were recognized, each of which proved possible to key out to species named in Beadle (1903) and were typified as appropriate. Detailed series and species descriptions were drawn up, as were keys to both series and species. Line illustrations for three of the species, county distribution maps and citation of representative specimens for all species were then prepared. This will be the first time that any of these species has been mapped in detail and we believe that this also is the case for two of the species illustrated.

Species concepts are morphological and based on a cluster of diagnostic characters for each taxon and unambiguous separation between each. In this respect it is worth noticing that, unusually for *Crataegus*, none of the taxa treated here have synonyms. This itself gives a measure of support to our species limits. No explicit data on breeding system was available for any species but recently Talent and Dickinson (2005) have produced an array of ploidy level data for taxa treated here, mainly derived from Lance collections. This did not help in arriving at our specific limits but has potential implications for a better understanding of the two series and relevant discussion is provided under the species treatments.

TAXONOMY

This part of the paper commences with a key designed to discriminate series *Bracteatae* and *Triflorae* from other sympatric series. It is followed by a conventional treatment of the two series and their constituent species with some discussion of each. The abbreviation LII refers to the leaf incision index or degree to which sinuses extend toward the midvein. Thus, an LII of 0% represents no lobing, 100% cut to the midvein.

ABBREVIATED KEY TO SERIES OF *CRATAEGUS* IN THE SOUTHEASTERN UNITED STATES

1. Short-shoot leaves lobed with veins to larger sinuses _____ ser. **Apiifoliae***, **Cordatae***, **Microcarpae***
1. Short-shoot leaves lobed or not, never any veins to sinuses.
   2. Fruit black; short-shoot leaves lacking lobes; thorns < 1cm long, recurved _____ ser. **Brevispinae***

2. Fruit red to yellow; short-shoot leaves lobed or not; thorns mostly 2–5 cm long (except some ser. *Lacrimatae* with very short thorns), straight to slightly recurved (sect. **Coccineae, sens. lat.**).
   3. Ultimate twigs normally not zigzag at any node.
      4. Short-short leaves usually < 1.6 × as long as wide; usually with 2–4 clearly defined lobes per side.
         5. All green plant parts highly glandular; flowers 20–30 mm wide; inflorescences few-flowered; stamens 10 or 30–45 _____ **ser. Triflorae**
         5. Only some green plant parts glandular; flowers 12–20 mm wide; inflorescences mainly 5–15-flowered; stamens ca. 10 or ca. 20 _____ **sect. Coccineae, sens. str.** (**ser. Molles, Coccineae, Tenuifoliae, Silvicolae, Pruinosae, Intricatae, Pulcherrimae*, C. flava**)
      4. Short-short leaves mostly 1.75–2 × as long as wide; usually quite unlobed, though sometimes with 1–2 very small notches per side or alternatively with somewhat undulate sides.
         6. Green plant parts mainly ± eglandular _____ **ser. Aestivales*, Crus-galli, Punctatae**
         6. Green plant parts highly glandular.
            7. Leaves glossy, ± coriaceous at maturity, usually very short-petiolate, 1–4 cm long.
               8. Fruit yellow to ruddy; calyx lobes as long as petals; flowers small (12–15 mm. wide); leaves 1–2 cm long _____ **ser. Parvifoliae***
               8. Fruit red; calyx lobes much shorter than petals; flowers larger (15–20 mm. wide); leaves 2–4 cm long _____ **ser. Bracteatae**
            7. Leaves ± matte, usually thin or at least not markedly coriaceous at maturity, long-petiolate; generally 3–6 cm wide and 3–8 cm long at maturity _____ **C. triflora (ser. Triflorae, p.p.)**
   3. Ultimate twigs always evidently zigzag at nodes _____ **ser. Lacrimatae, sens. lat.**

* treated in other papers in this series

DIRECT COMPARISON OF SERIES BRACTEATAE AND TRIFLORAE

1. Flowers (15–)20–25 mm wide; stamens ca. 20 or 22–25; leaves ± coriaceous at maturity; bushes with main stem dominance _____ **ser. I. Bracteatae**
1. Flowers 25–30 mm wide; stamens 10 or 30–45; leaves generally thin; multi-stemmed bushes _____ **ser. II. Triflorae**

series **Bracteatae** Sarg. ex Rehder, Man. cult. trees, 1940:363. TYPE SPECIES: *C. harbisonii* Beadle.

Group without rank *Bracteatae* Sarg., Silva Suppl. 13:34. 1902.

Medium-sized shrubs; thorns 2–4 cm long, somewhat stout, dark and ± shiny at 2 yrs. old. Leaves deciduous, fairly short-petiolate, less than 1/4 length of leaf blade, pubescent, glandular-stipitate; blades 2–7 cm long, broad-elliptic to obovate or roughly suborbiculate in general shape; usually unlobed, except sometimes with 2–4 lobed apiculi; margins regularly and strongly toothed, the teeth glandular and near the base usually stipitate-glandular; venation craspedodromous with 5–7 pairs of lateral veins; ± appressed-pubescent above young, persisting or ± glabrescent, below hairy mainly on the veins; texture coriaceous. Inflorescences 3–12 flowered, sometimes on leafy short shoots of the season; branches densely tomentose, bearing semi-persistent, large, ligulate, gland-bordered, or smaller, caducous, membranous, bracteoles. Flowers 20–25 mm wide; hypanthium externally tomentose; calyx lobes glandular-pectinate; stamens 20–25, anthers usually ivory; styles 3–5. Fruits 1-few per infructescence, ca. 10–14 mm broad, hairy, red to ruddy; calyx lobes long, conspicuous, patento-reflexed; nutlets 3–5, dorsally furrowed, laterally smooth.

Habitat and Distribution.—This series comprises one fairly common species, *Crataegus ashei*, and one very rare species, *C. harbisonii*, together occurring from Louisiana to Alabama in the piedmont and north into Tennessee and the Virginia Blue Ridge.

They are found in brushy places including prairie margins and open woodland. Unequivocal ploidy levels obtained are all tetraploid.

Comment.—The *Bracteatae* are characterized by relatively few-flowered and fairly large-flowered inflorescences and possess very glandular petioles, leaf margins, pedicels and calyx lobe margins, which parts are also usually very hairy. They share these characteristics with the remarkable series *Triflorae* to which they appear to be related. Number of flowers per inflorescence is not a good discriminator among the species mentioned. *Crataegus harbisonii* may bear its inflorescences on side-shoots of the season. The leaves of ser. *Bracteatae* have longer petioles than the superficially similar ser. *Crus-galli*.

KEY TO SPECIES

1. Leaf blades never, or scarcely perceptibly, lobed (LII 0–5%); marginal teeth 1.5 mm long; 2-yr. old thorns fine; all inflorescences borne on perennial spur-shoots; bracteoles less persistent, sometimes membranous _____ **1. C. ashei**
1. Some larger leaf blades evidently, if shallowly, lobed (max. LII ca. 10–15%); marginal teeth 2 mm long; 2-yr. old thorns quite stout; inflorescences quite often on leafy side-shoots of the season; bracteoles particularly persistent, often subherbaceous _____ **2. C. harbisonii**

Crataegus ashei Beadle, Biltmore Bot. Stud. 1:339. 1900. (**Figs. 1, 2**). TYPE: U.S.A. ALABAMA. Montgomery Co.: Montgomery, between the fairgrounds and the river; May 14 1900, *C.D. Beadle 2275* (LECTOTYPE here designated: US 963476; ISOLECTOTYPES: exist but n.v.).

Bushes to 5 m tall; thorns few to numerous, 2–3 cm long at 2 yr. old, shiny, very dark brown to black, somewhat slender, ± straight; extending twigs densely pubescent, at 1 yr old tan to chestnut, somewhat shiny; older gray. Leaves deciduous; petioles 0.75–1.5 cm long, densely pubescent, bearing stipitate glands; blades 3–6 cm long, elliptic; acute to subacute at the apex, base cuneate into the winged upper part of the petiole; generally no sign of lobing; margins with even, triangular, acute teeth about 1.5 mm long, the teeth gland-tipped, those at the base of the blade glands stipitate; venation craspedodromous 5–7 lateral veins per side; persistently scabrous-hairy above, below thinly pubescent to glabrous on the surface, veins hairy; upper surface shiny mid-green. Inflorescences 3–10 flowered, not on leafy short shoots of the season; branches densely villous, bearing linear, herbaceous to membranous, gland-margined bracteoles. Flowers (15–)20–23 mm wide; hypanthium externally tomentose; calyx lobes narrow-triangular, 6–7 mm long, abaxially pilose, margins glandular-pectinate; petals ± circular, white; stamens 20(–25), anthers cream(pink); styles 3(–5) with bristly hairs at the base. Fruit 10–14 mm wide, subglobose, dense short-pubescent, orange-red to deep red; calyx lobes long, patent-incurved; nutlets 3(–5), dorsally grooved, sides smooth.

Common name.—Ashe's hawthorn.

Habitat and Distribution.—This is a plant of brushy places and open woodland understorey occurring from Louisiana to Alabama and is apparently fairly scarce. Recently (2000) JBP has come across a highly disjunct record for the Virginia Blue Ridge.

Comment.—*Crataegus ashei* has quite often been confused with both *C. triflora* and *C. harbisonii*. It differs substantially from *C. triflora* in its different growth habit, smaller flowers, 20–24 stamens, and unlobed, generally more coriaceous and shiny leaves. It is, however, much more similar to *C. harbisonii*, mainly differing in being smaller in its vegetative parts, lacking reproductive side-shoots of the season and by having quite entire leaves—see the key. *Crataegus ashei* often has a growth habit not unlike generally sympatric *C. berberifolia*, with ± layered branching and smallish leaves. The seven specimens cited in Talent and Dickinson (2005) are all tetraploid.

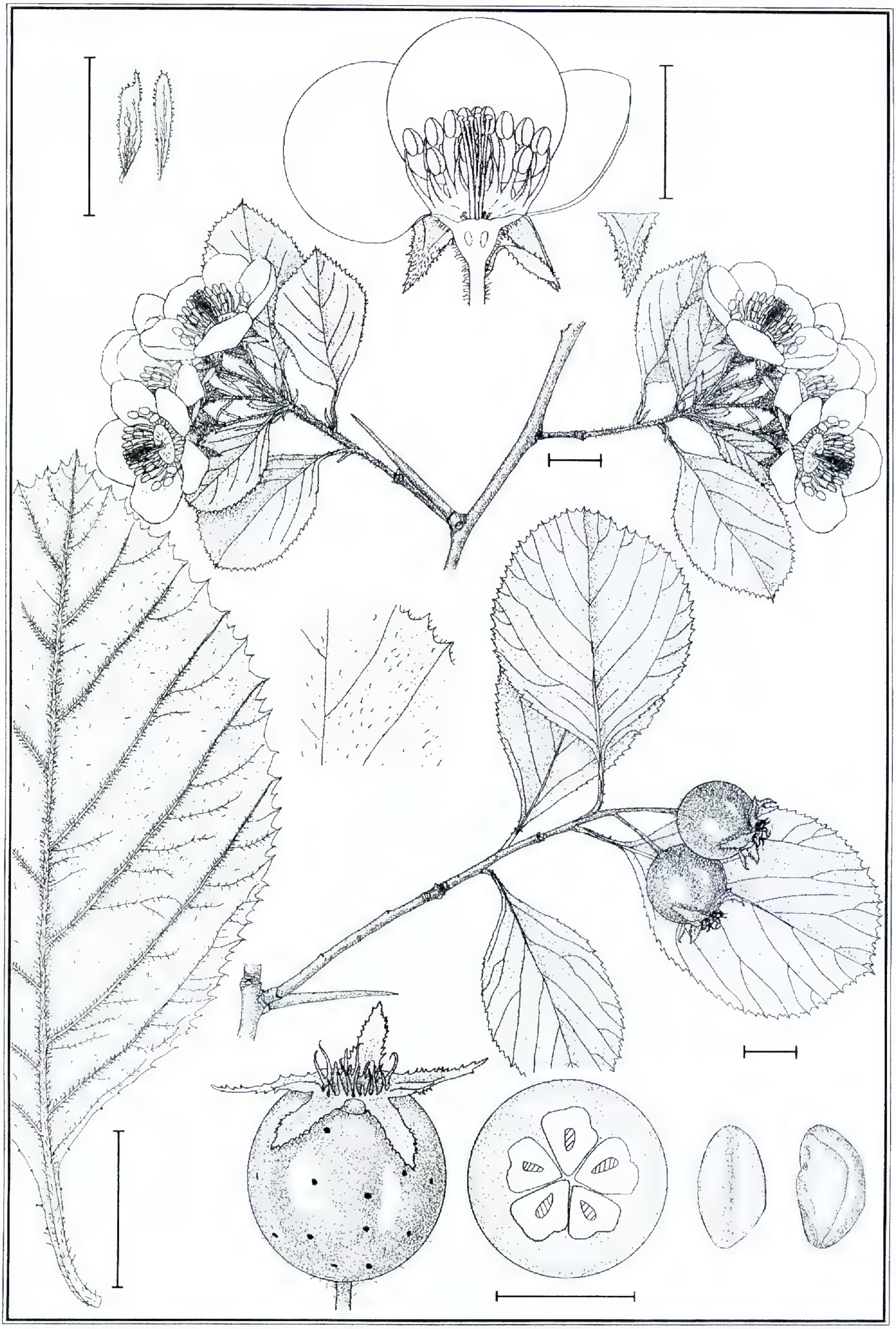


FIG. 1. Line illustration of *C. ashei*. Scale bars = 1cm; S. Laurie-Bourque del.

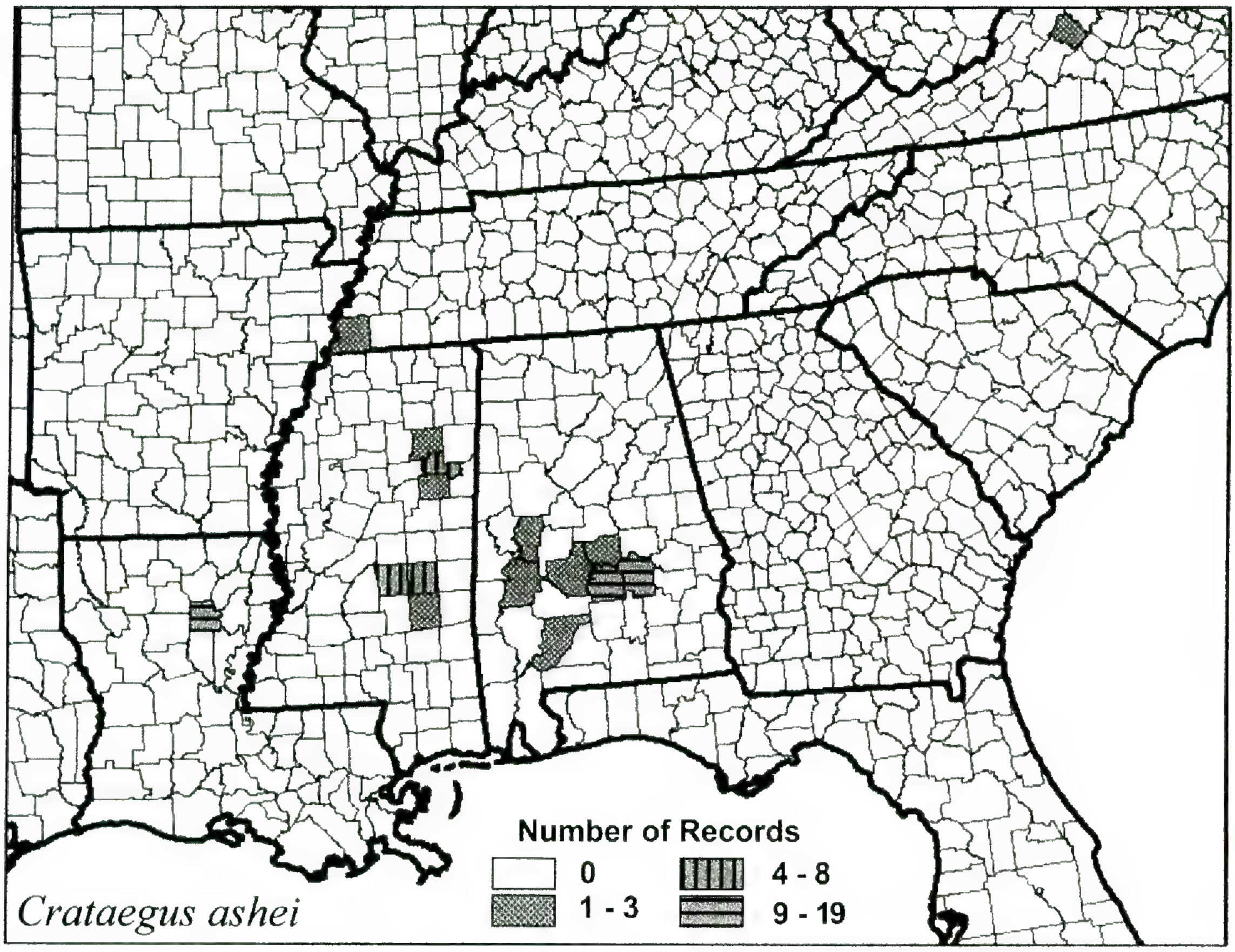


FIG. 2. County level distribution map of *C. ashei*.

2. Crataegus harbisonii Beadle, Bot. Gaz. 28:413. 1899. (**Fig. 3**). TYPE: U.S.A. TENNESSEE. Davidson Co.: W Nashville, hilltop in limestone soil, May 29 1899, *T.G. Harbison 181* (LECTOTYPE here designated: US 969473). Specimens of *T.G. Harbison 181* (= same tree) exist collected at other times.

Bushes or trees to 8 m tall; extending shoots sparsely pilose; 1 year old shoots becoming smooth, chestnut-brown; thorns 3–4 cm long, stout, ± straight, glossy dark brown or near black. Leaves deciduous; petioles 1/2–1 cm long, thinly pilose, gland-dotted, winged above; blades 4–7 cm long, broadly elliptic to ovate in general shape; tip acute, base cuneate; entire or with up to 4 very shallow lobes per side; margins strongly (ca. 5 teeth per cm) double-serrate with outward pointing teeth, these gland-tipped early; venation craspedodromous with 6–7 pairs of lateral veins; rather shiny and coriaceous at maturity, appressed-pubescent above when young, when mature pubescent on the veins below. Inflorescences 5–12 flowered, frequently on leafy short shoots of the season; branches pilose, bearing 7–18 mm long, 2–4 mm broad, semi-persistent, subherbaceous, glandular-pectinate to glandular-serrate bracteoles; anthesis early May in Nashville, Tennessee. Flowers 20–25 mm wide; hypanthium pubescent externally; calyx lobes lanceolate, glandular-laciniate; petals ± circular, white; stamens 20, anther color cream to light yellow; styles 3–5. Fruit mostly 12–22 mm wide in recently observed living material, ± globose, pubescent, orange-red to red; calyx lobes semi-persistent, patent-reflexed; nutlets 3–5, dorsally furrowed, sides ± plane.

Iconography.—Lance and Phipps (2000).

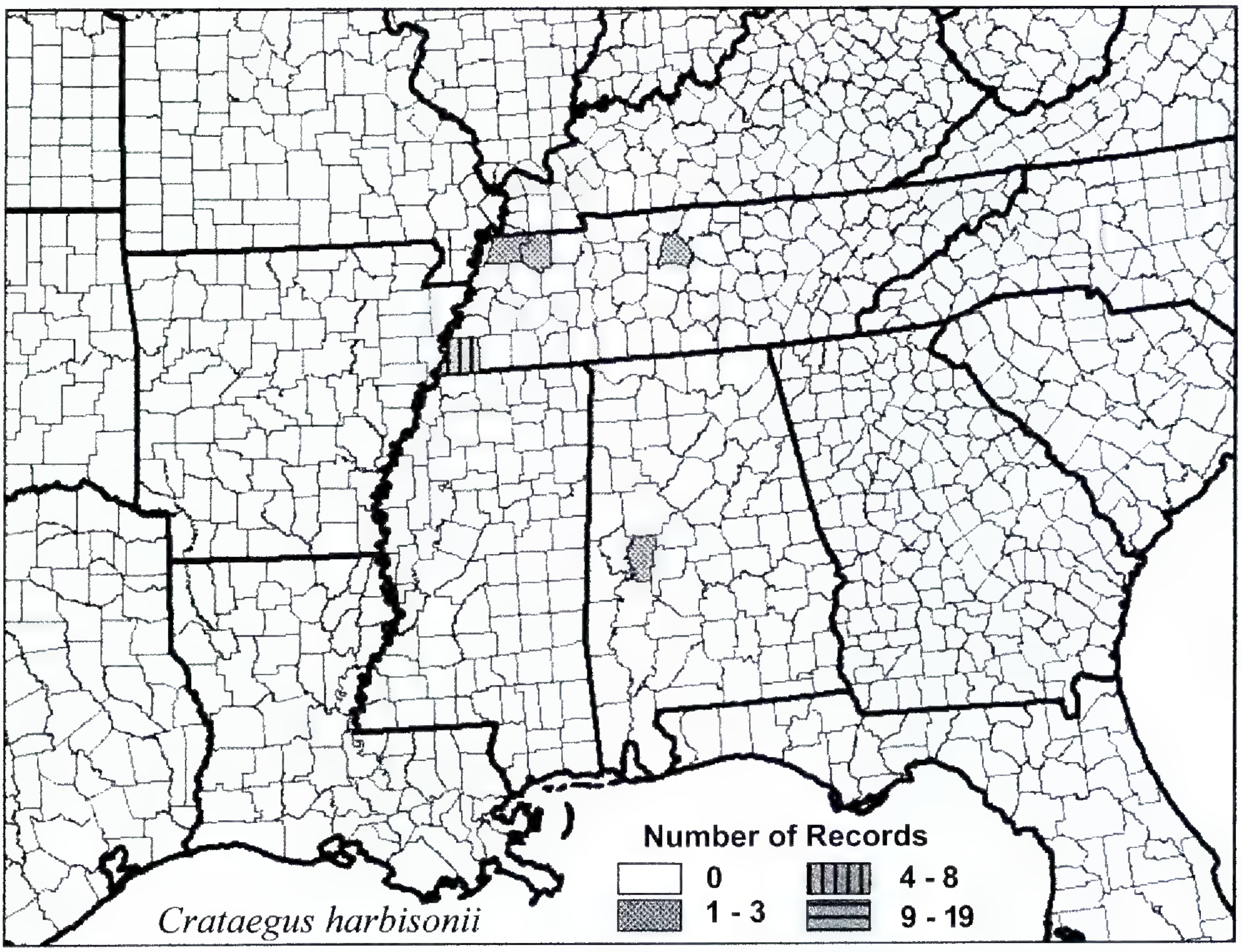


FIG. 3. County level distribution map of *C. harbisonii*

Common name.—Harbison's hawthorn.

Habitat and Distribution.—This is a very rare, perhaps extinct species from wooded hills near Nashville, Tennessee and one locality in Alabama though its most reliable location is in cultivation in North Carolina and elsewhere due to strenuous efforts at propagation by the second author.

Comment.—Harbison's Hawthorn is very similar to *C. ashei* and could perhaps be thought of as a particularly robust form of that species. However, see discussion of the former species for differences, which we consider support specific rank. It has also similarities to *C. triflora* (ser. *Triflorae*) but is easily distinguished from that species by characteristics of growth-habit (see key), by its smaller flowers (except in the Louisiana and some Mississippi forms of *triflora*) with fewer stamens and by the much more coriaceous leaves with much larger and more distant teeth and among the most persistent bracteoles in the genus, a feature which led to the creation of series *Bracteatae*. All five specimens cited in Talent and Dickinson (2005), all originating from a tiny population in Nashville, Tennessee, are tetraploid.

II. ser. **Triflorae** (Beadle ex C.K. Schneid.) Rehder, Man. cult. Trees, 1940:364. TYPE SPECIES: *C. triflora* Chapm.

group without rank *Triflorae* Beadle in J.K. Small, Fl. SE US, 1903:533.
sect. *Triflorae* (Beadle) C.K. Schneid., Ill. Handb. Laubholzk. 1:797. 1906.

Medium-sized shrubs; thorns 2–4 cm long, ± slender, dark gray or blackish at 2 yrs. old.

Leaves deciduous; petioles distinct, about 1/3 length of leaf blade, pubescent, glandular-stipitate; blades 3–8 cm long, elliptic to nearly suborbiculate in general shape; unlobed to shallowly 2–4-lobed per side (max. LII 10–15%); margins regularly and sharply toothed, the teeth glandular and near the base usually stipitate-glandular; venation craspedodromous with 5–7 pairs of lateral veins; ± hairy above until maturity, hairy mainly on the veins below; texture usually thin. Inflorescences 2–6(–12) flowered, normally on leafy short shoots of the season; branches densely tomentose, intermixed with stipitate glands, bearing herbaceous, semi-persistent, large, ligulate, gland-bordered bracteoles. Flowers 25–30 mm wide; hypanthium externally tomentose; calyx lobes broad, triangular, deeply glandular-serrate, rather foliaceous; stamens ca. 10 or 30–45, anthers usually ivory; styles 3–5. Fruits 1-few per infructescence, ca. 10–15 mm broad, subglobose to obovoid, hairy, red to ruddy; calyx lobes long, conspicuous, patento-reflexed; nutlets 3–5, dorsally furrowed, laterally smooth.

Habitat and Distribution.—This series comprises one fairly common (*Crataegus triflora*) and one very rare (*C. austromontana*) species, occurring from Louisiana to Georgia in the piedmont and north into Tennessee with an outlier in Arkansas. They are found in brushy places including prairie margins and open woodland, as well as being able to tolerate considerable shade.

Comment.—The *Triflorae* constitute a distinctive series characterized by few-flowered and large-flowered inflorescences often borne on leafy short shoots of the season as well as very glandular petioles, leaf margins, pedicels and calyx lobe margins, which parts are also usually very hairy. The most similar series is ser. *Bracteatae*. The 30–45 stamens of *C. triflora* are unique in the genus. Also characteristic are the multiple stems lacking main trunk dominance and the inflorescences which are quite often being borne on lateral shoots of the season.

KEY TO SPECIES

1. Leaf blades nearly as broad as long, shallowly lobed; stamens 10 _____ **1. C. austromontana**
1. Leaf blades generally much longer than broad, seldom lobed; stamens 30–45 _____ **2. C. triflora**

Crataegus austromontana Beadle, Bot. Gaz. 28:412. 1899. (**Figs. 4, 5**).TYPE: U.S.A. ALABAMA. De Kalb Co.: Valley Head, Sep 1899, *C.D. Beadle 1288* (LECTOTYPE here designated: DOV).

Bushes, to 4 m tall; twigs of the season densely pubescent; 1 year old twigs brown; thorns not recorded. Leaves deciduous; petioles about 30% length of blades, densely pubescent, glandular; blades 4–7 cm long, broad-ovate to suborbicular in general outline; shallowly 3(–4)-lobed, largest LII ca. 15%; tip subacute, the base cuneate tapering into a upper petiolar wing; margins sharply toothed throughout, the teeth gland-tipped; venation craspedodromous, ca. 5 veins per side; when young appressed hairy above, especially on the veins, below thinly pubescent except on the veins, when older, surfaces generally glabrescent. Inflorescences ca. 3-flowered, on leafy short shoots of the season; branches dense-tomentose and bearing caducous, linear, membranous, gland-margined bracteoles; flowering 2 May 1911 at Valley Head, Alabama. Flowers ca. 25 mm wide; hypanthium externally densely tomentose; calyx lobes ca. 7 mm long, narrow triangular, herbaceous, margins glandular-pectinate, adaxially pubescent; petals broadly elliptic, white; stamens 10, anthers cream; styles 3–5. Fruit 12–15 mm wide, ± globose, pubescent, red; calyx-lobes conspicuous; nutlets 3–5, dorsally grooved, sides plane.

Common name.—Valley Head hawthorn.

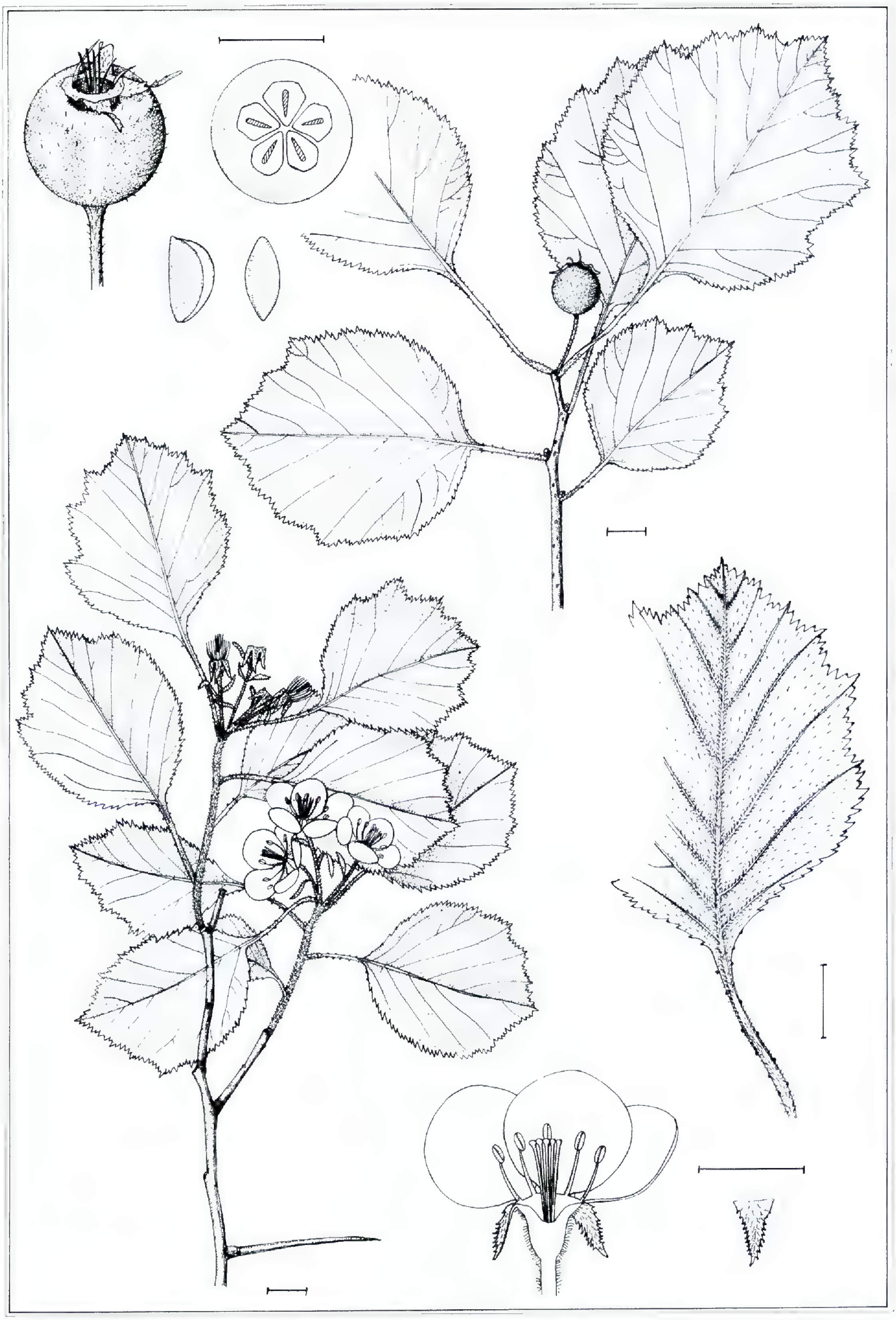


FIG. 4. Line illustration of *C. austromontana*. Scale bars = 1cm; S. Laurie-Bourque del.

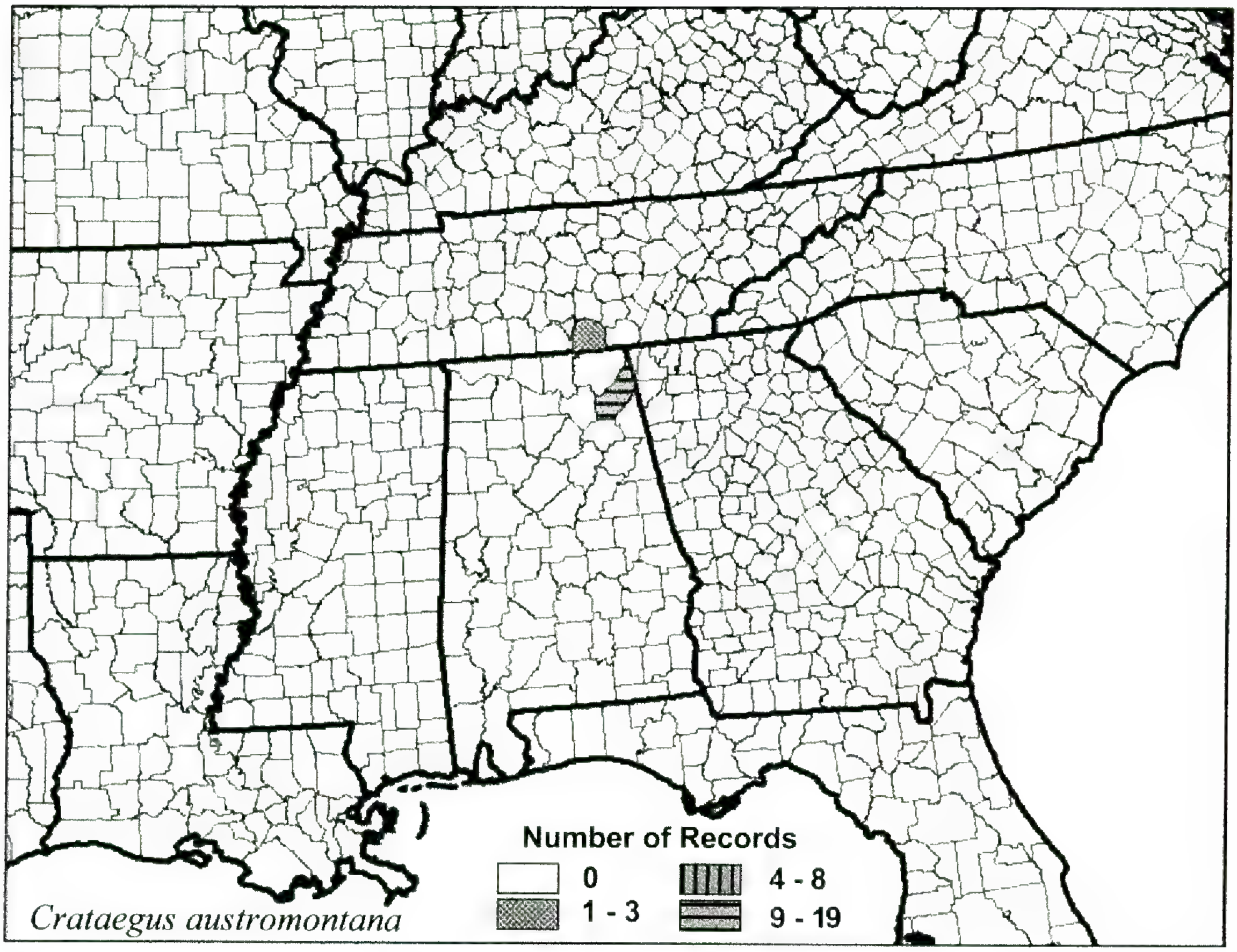


FIG. 5. County level distribution map of *C. austromontana*

Habitat and Distribution.—This is a very rare or possibly extinct species not collected since 1916. Beadle (1899) reported that it occurred throughout the Sand Mountain region of Alabama and had also been collected in the Cumberland Mountains and hill country of eastern and middle Tennessee.

Comment.—It is generally similar to *Crataegus triflora* but has broader, generally larger and more deeply lobed leaves and only 10 stamens.

2. Crataegus triflora Chapman, Fl. S US, 2nd Suppl. 1892:684. **(Figs. 6, 7).** TYPE: U.S.A. GEORGIA: 'Mountains of Georgia,' flowering specimen, 1883 or earlier, *Chapman Herbarium 847* (NEOTYPE here designated: A). A quote from a letter on the type sheet suggests the last possible date for this collection.

Multistemmed shrubs to 4 or 5 m tall; twigs of current season appressed-pubescent, 2 year old twigs brown; older gray; thorns usually 2–4 cm long, ± slender, ± straight, dark gray or blackish; compound thorns on trunk. Leaves deciduous; petioles about 1/3 length of blades, dense pubescent, also stipitate-glandular; blades 3–8(–10) cm long, broadly elliptic in general shape; entire or shallowly and somewhat irregularly 1–3(–4)-lobed per side; tip acute; base cuneate, somewhat tapered into the petiole; margins finely serrate (ca. 10 teeth per cm), the teeth usually ca. 1 mm long, gland-tipped; venation craspedodromous with 5–7 veins per side; appressed-pubescent above and pubescent below when young, only veins below pubescent when old; texture thin. Inflorescences 2–6(–12) flowered branches dense-tomentose, bearing caducous, linear, thin, herbaceous, gland-bordered bracteoles; flowering late April–early May. Flowers 25–30 mm wide; hy-

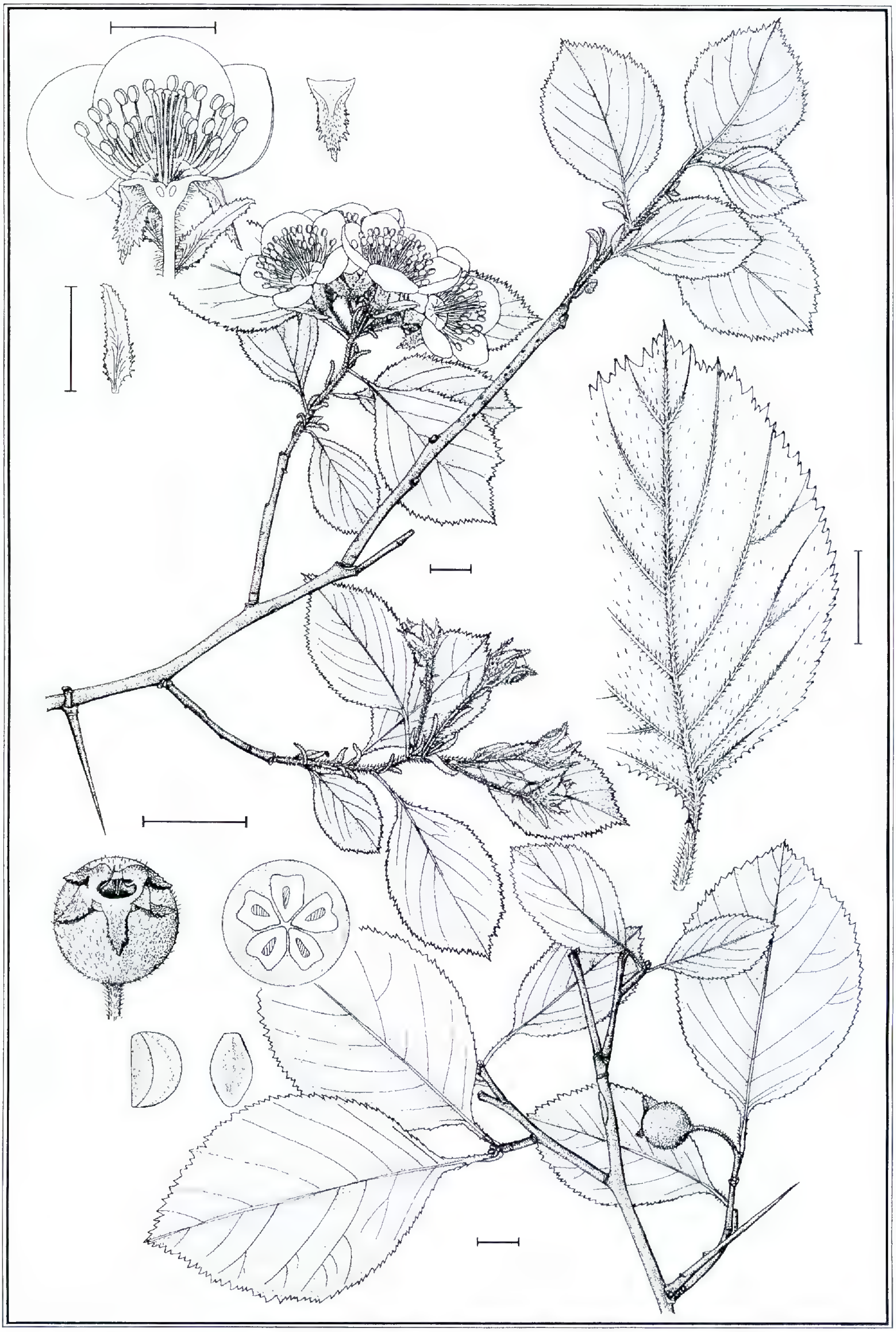


FIG. 6. Line illustration of *C. triflora*. Scale bars = 1cm; S. Laurie-Bourque del.

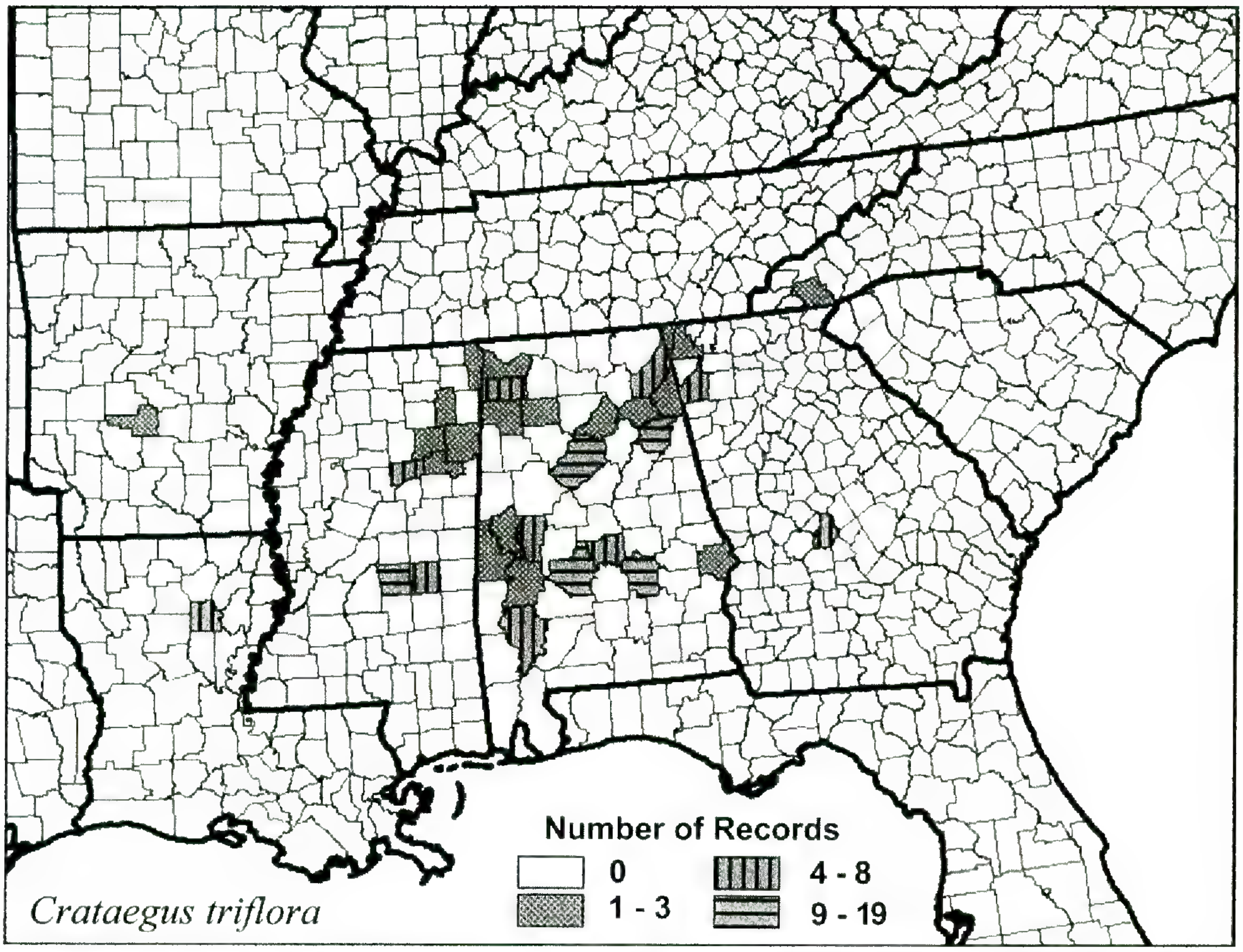


Fig. 7. County level distribution map of *C. triflora*

panthium externally densely tomentose; calyx lobes 8–10 mm long, herbaceous, glandular-pectinate, abaxially densely pubescent; petals ± circular, white; stamens ca. 30–45 (47 in *Phipps & Herring 8130*!), anthers cream; styles ca. 4. Fruit ca. 12–15 mm high, subglobose to obovoid, pubescent, ruddy to deep or bright red, occasionally coral-red; reflexed calyx lobes long, persistent; nutlets dorsally grooved, sides smooth.

Iconography.—Color illustration: plate 64, Phipps et al. (2003).

Common name.—Three-flower hawthorn.

Habitat and Distribution.—This is a local plant known from six southeastern states which extends from Arkansas and Louisiana (rare in both) and Mississippi to Georgia, having also been found in Tennessee (also rare). It is only rarely locally abundant. It is found scattered in gaps in hardwoods, pine forest, cattle-grazed scrub on blackland soils, and sometimes prairie margins. Literature records from Virginia are probably *C.* ×*vailiae*.

Comment.—The protologue reads 'cliffs of Coosa R., Rome', suggesting that this should be the type locality but although this became a popular collection site for the species we have seen no material from there of appropriate date for lectotypification. Accordingly, we neotypify as above. *Crataegus triflora* is generally an open-grown, multi-stemmed, rather lax bush. Its flowers are among the most spectacular of all *Crataegus*, in size reminiscent of a wild rose. Although so dramatic and distinct a plant, it unaccountably disappeared from floras between Beadle (1903) and Phipps in Wofford (1989). A fairly rare form from central Mississippi has rather ovate leaves which may possess a nearly truncate base. This quite distinctive morph also possesses much larger marginal leaf teeth than

the typical form, more like *C. ashei*, but it has the flowers of *C. triflora*. Infrequent specimens with smallish, unlobed leaves may look very like *C. collina* if vegetative but are easily distinguished by their deeply glandular-serrate calyx lobes, and highly glandular leaf margins and petioles. Records from Tennessee generally have relatively broader leaves with unusually large marginal teeth. Variability in leaf-lobing is also a notable feature though so far it has been correlated with nothing else. The discovery of the large stamen number of *C. triflora* is first recorded in Phipps et al. (2003). The inflorescences may be much more floriferous then the name suggests. Another interesting feature of *C. triflora* is that it frequently produces inflorescences on fresh 2–5 cm long peduncles of the season that arise from woody extension shoots instead of at the tips of woody short shoots as is characteristic of most hawthorn species. Such a feature, rare in *Crataegus*, is universal in *Mespilus canescens*. Ploidy level determinations in Talent and Dickinson (2005) suggest that tetraploidy and triploidy are reasonably common but that diploidy is rare in *C. triflora*. The much smaller leaves and flowers of Caldwell parish, Louisiana populations as well as the diversity in leaf shape elsewhere, may possibly one day be shown to correlate with ploidy level variations but at present this is not detected.

APPENDIX

Consolidated database of cited specimens arranged alphabetically by species, state and county

Crataegus ashei Beadle (number of records: 52)

ALABAMA. Autauga Co.: prairie, Jones Bluff, N of Alabama River, S of Peace, 29 May 2000, *R. Lance 2096, 2097, 2105* (UNC); same loc, May 1996, *J. Allison 9114a, 9114b, 9116* (GA). **Dallas Co.:** Old Cahawba Archaeological Park, SW of Selma, Old Negro Cemetery, 32°18'N, 87°06'W, 14 Apr 1999, *J.B. Phipps 7895* (UWO). **Hale Co.:** Gallion, 25 May 1892, *C. Mohr s.n.* (UNA). **Lowndes Co.:** NE of White Hall Holy Ground Battlefield Memorial Park, 32°23'N, 86°44'W, 14 Apr 2000, *J.B. Phipps 8139* (UWO); NE of White Hall Holy Ground Battlefield Memorial Park, 32°23'N, 86°44'W, 14 Apr 2000, *J.B. Phipps 8138* (UWO); ca. 8 mi W of Gordonville, on N side of Co. Rd. 12, edge of prairie 2 mi W of curve of Hwy 12 from N to W in section 27, section 28, just E of stream near BM 317.5, 29 May 1999, *R. Lance s.n.* (UWO); NW of Hayneville (W of Montgomery) Holy Ground Battlefield Park (U.S. Army Corps. of Engineers), 28 Apr 1996, *J.R. Allison and A. Schotz 9118* (UWO); NW of Hayneville, Holy Ground Battlefield, 2 Apr 1997, *R. Lance s.n.* (UWO); NW of White Hall, Holy Ground Battlefield Memorial Park, 32°23'N, 86°44'W, 11 Apr 1998, *J.B. Phipps 7692* (UWO); NW of White Hall, Holy Ground Battlefield Memorial Park, 32°23'N, 86°44'W, 10 Apr 1998, *J.B. Phipps 7676* (UWO); NW of Hayneville (W of Montgomery) Holy Ground Battlefield Park (U.S. Army Corps. of Engineers), 1996/09, *A. Schotz s.n.* (UWO); NW of White Hall, Holy Ground Battlefield Memorial Park, 32°23'N, 86°44'W, 24 Sep 1996, *R.J. O'Kennon and R. Lance 14453* (UWO). **Marengo Co.:** near Allenville, 14 Apr 1931, *E.J. Palmer 38697* (MO); Co. Rd. 51, 2.5 km N of Co. Rd. 54, 32°27'N, 87°40'W, 12 Apr 1999, *J.B. Phipps 7871* (UWO). **Montgomery Co.:** Montgomery, 23 Sep 1905, *T.G. Harbison 10041* (NCU); N side of US 80 at Caney Cr., to the NE of Montgomery airport, ca. 50 ft NW of 8141, visible from W side of cut, 32°19'N, 86°23', 14 Apr 2000, *J.B. Phipps 8142* (UWO); N side of US 80 at Caney Cr., to the NE of Montgomery airport, ca. 50 ft NW of 8141, visible from W side of cut, 32°19'N, 86°23'W, 14 Apr 2000, *J.B. Phipps 8143* (UWO); E Montgomery Airport at jet of Caney Cr. and US Hwy 80, in utility right-of-way, ca. 200–250 ft E of creek, 7 Apr 1999, *R. Lance s.n.* (UWO); N side of US80 at Caney Creek, N Side of Rd., 32°19'N, 86°23'W, 12 Apr 1999, *J.B. Phipps 7878* (UWO); no locality, 23 Sep 1905, *T.G. Harbison 10041* (UNC); N side of US 80 at Caney Creek, 32°18'N, 86°23'W, 1 Oct 1998, *J.B Phipps and R. Lance 1780* (UWO); US 80 at Caney Creek, 32°19'N, 86°23'W, 24 Sep 1999, *R.J. O'Kennon and R. Lance 14452* (UWO); Montgomery, 14 May 1900, *C.D. Beadle 2275* (US); Montgomery, 28 Sep 1899, *no collector* (US); Montgomery, 8 Aug 1895, *C.D. Beadle B895* (US); no locality, 14 May 1900, *C.D. Beadle 2275* (US). **Unknown Co.:** Ranger's Station, 23 May 1925, *W.W. Ashe s.n.* (NCU).

LOUISIANA. Caldwell Parish: E of Copenhagen and La. 849 and W of Ouachita River S of Columbia, Sec. 13. T12N, R4E, 29 Jul 1987, *R.D. Thomas 101097* (USCH, UWO); E of Copenhagen and La. 849 and W of Ouachita River S of Columbia, Sec. 13. T12N, R4E, *1* Aug 1989, *R.D. Thomas 111868* (USCH); ca. 2 km due E of Copenhagen, 92°02'W, 32°02'N, 10 Apr 1984, *J.B. Phipps and T.C. Wells 5366* (UWO); ca. 2 km due E of Copenhagen, 92°02'W, 32°02'N, 10 Apr 1984, *J.B. Phipps and T.C. Wells 5369* (UWO); ca. 2 km due E of Copenhagen, 92°02'W, 32°02'N, 10

Apr 1984, *J.B. Phipps and T.C. Wells 5367* (UWO); ca. 2 km due E of Copenhagen, 92°02'W, 32°02'N, 10 Apr 1984, *J.B. Phipps and T.C. Wells 5365* (UWO); ca. 2 km due E of Copenhagen, 92°02'W, 32°02'N, 30 Oct 1985, *J.B. Phipps and P.G. Smith 5875* (UWO); E of Copenhagen and La. 849 and W of Ouachita River S of Columbia, Sec. 13, T12N, R4E, 17 Nov 1985, *R.D. Thomas and B. Liles (MD) 95070* (UWO); E of Copenhagen and La. 849 and W of Ouachita River S of Columbia, Sec. 13, T12N, R4E, 3 Aug 1982, *R.D. Thomas et al. 82032* (UWO). **Sabine Parish:** Pleasant Hill Rd./ Richmond Rd., 27 Mar 1918, *R.S. Cocks 3342* (NO).

MISSISSIPPI. Chickasaw Co.: MS 41 to SE of Natchez Trace Parkway, 34°05'N, 88°52'W, 13 Apr 1998, *J.B. Phipps 7713* (UWO). **Clay Co.:** Co. Rd. 83 at trash dump, Kilgore Hills area NE of Sparta, 33°48'N, 88°56'W, 30 Sep 2000, *J.B. Phipps and R. Lance 8189* (UWO); Co. Rd. 83, 0.5 mi beyond trash dump, Kilgore Hills area NE of Sparta, 33°48'N, 88°56'W, 30 Sep 2000, *J.B. Phipps and R. Lance 8191* (UWO); Co. Rd. 83 mi after trash dump, Kilgore Hills area NE of Sparta, 33°48'N, 88°56'W, 30 Sep 2000, *J.B. Phipps and R. Lance 8192* (UWO); Kilgore Hills, on SE side of gravel Rd. 83, NE of Sparta (eastbound gravel rd. off Hwy 389 just N of Sparta), just NE of Chickasaw Co. line, S7 NW4, SW4 T15S, R3E, 88°56'W, 1 Jun 2000, *R. Lance 00-210* (UWO); along Co. Rd. 8 E Side of Rd, Ca. 3.45 mi E of Co. Rd. 389, 33°47'20"N, 38°55'45"W, 01 Sep 2001, *R. Lance 2146* (UWO); ca. 4.0 mi SSE of McCondy, just W of NE-SW gravel rd. ca. 0.5 mi SW of intersection with Hwy 47, T15s R4E, S15 SE4, 10 Jul 1985, *T.E. Smith et al. 1417* (UWO). **Jasper Co.:** ca. 5 mi S of Lake near Tanglewood, N side of Rd., 32°10'N, 89°17'W, 12 Apr 1998, *J.B. Phipps 7707* (UWO). **Newton Co.:** Black Prairie Region, 4 mi S of Lawrence, 12 Jun 1957, *G.R. Cooley and J.D Ray, Junior 5358* (USF); prairie to S of Moffett Rd., 32°14'N, 89°17'W, 16 Apr 1999, *J.B. Phipps 7908* (UWO); E of Tanglewood and ca. 3 mi S of Ponderosa Landing Strip, 32°17'N, 89°17'W, 4 Oct 1998, *J.B. Phipps and R. Lance 7811* (UWO); small prairie on S side of Moffett Rd. (branching off Gordy Rd.), 32°15'N, 89°16'W, 25 Sep 1999, *J.B. Phipps et al. 8076* (JWO). **Monroe Co.:** Becker Bottom, date and collector missing (IBE). **Oktibbeha Co.:** Starkville, 4 Sep 1894, *Mercer 2813* (CM). near Clayton Village, just E of MS State (2nd Rd. after Wilkins Rd.), 33°28'N, 88°45'W, 15 Apr 1999, *J.B. Phipps 7905* (UWO); Clayton Village, E of MS State (2nd Rd after Wilkins Rd.), 33°28'N, 88°45'W, 5 Oct 1998, *J.B. Phipps and R. Lance 7819* (UWO). **Scott Co.:** N of Sherman Hill, Durand Oak Prairie, 31°17.5'N, 89°23'W, 13 Apr 2000, *J.B. Phipps and J. Herring 8137* (UWO); NE of Sherman Hill, just S of Durand Oak Prairie Forest Rd. 55IF ca. 3.5 mi in, 31°17.5'N, 89°23'W, 13 Apr 2000, *J.B. Phipps and J. Herring 8134* (UWO); ca. 5 mi S of Lake near Tanglewood, N side of Rd., 32°17'N, 89°18'W, 12 Apr 1998, *J.B. Phipps 7702* (UWO); NW side of Sherman on FR 551F (gated) off 551, 32°17'N, 89°22'W, 25 Sep 1999, *J.B. Phipps et al. 8081* (UWO). **Smith Co.:** S of Trenton, Bienville National Forest, 3 Nov. 2005, *R. Lance 3025* (NCU).

VIRGINIA. Amherst Co.: Blue Ridge Parkway, along Otter Creek 3.3 mi from Rt. 130, 17 May 1957, *R.S. Freer 2474* (LYN).

Crataegus austromontana Beadle (number of records: 9)

ALABAMA. De Kalb Co.: Valley Head, 4 Oct 1916, *T.G. Harbison 12* (A, NCU); Valley Head, 2 May 1911, *T.G. Harbison 537* (A, CM, UWO); Valley Head, Sep 1899, *C.D. Beadle B1288* (DOV); Valley Head, 1911, *T.G. Harbison 3382* (A); Valley Head, 10 May 1900, *C.D. Beadle s.n.* (A); Valley Head, 1911, *T.G. Harbison 663* (A).

TENNESSEE. Franklin Co.: near Cowan, 12 May 1900, *no collector 42244* (A).

Crataegus harbisonii Beadle (number of records: 9)

ALABAMA. Hale Co.: Gallion, 4 Oct 1898, *C. Mohr s.n.* (ALU). **Montgomery Co.:** N side of US 80 at Caney Creek, 10 Apr 1998, *J.B. Phipps 7674* (UWO); same oc., 1 Oct 1998, *R. Lance, s.n.* (UWO); same loc., 12 Apr 1999, *J.B. Phipps 7879* (UWO).

TENNESSEE. Davidson Co.: W Nashville, 24–25 Sep 1909, *W.W. Eggleston 5153* (CM). **Obion Co.:** near Samburg, 26 Jun 1948, *A.J. Sharp, E. Clebsch, A. Clebsch, and S. Fairchild 8007* (TENN). **Shelby Co.:** N edge of Shelby Forest, 19 Aug 1947, *A.J. Sharp, E. Clebsch, and A. Clebsch 6463* (TENN); roadside, NW of Millington, 29 Jun 1948, *A.J. Sharp, S. Fairchild and E. Clebsch 8143* (TENN). **Weakley Co.:** N of Gardner, 23 Jun 1948, *S. Fairchild, E. Clebsch and A. Clebsch 7788* (TENN).

Crataegus triflora Chapm. (number of records: 133)

ALABAMA. Autauga Co.: between Jones Bluff and Ivy Creek, S of Peace and N of Alabama River, 29 May 2000, *R. Lance 2095, 2098, 2100, 2101, 2102, 2103, 2104* (UNC); Jones Bluff, 28 Apr 1996, *J. Allison 9114a, 9114b, 9116* (GA). **Blount Co.:** by I-65 ca. 5 mi N of Warrior, 23 May 1979, *R. Kral 63701* (UWO). **Calhoun Co.:** near Anniston, Area 15D Quarry, Ft. McClellan, 22 Apr 1988, *R. Smith and D. Spalding 3* (UWO); Fort McClellan Military Reservation, N of Anniston, 2 Jul 1998, *R. Smith and D. Spalding s.n.* (UWO); Fort McClellan Military Reservation N of Anniston 85°46'W, 33°42'N, 2 Jul 1998, *R. Smith and D. Spalding s.n.* (UWO); near Anniston Area /SD Quarry [15] Fort McClellan 85°46'W, 33°42'N, 22 Apr 1998, *R. Smith and D. Spalding 5* (UWO); Fort McClellan Military Reservation N of Anniston 85°46'W, 33°42'N, 8 Apr 1998, *J.B. Phipps 7644* (UWO); ca. 4.8 air m NE of Calhoun Co. Courthouse, Anniston, Fort McClellan Military Reservation, 13 Aug 1995, *J.R. Allison et al. 8917* (UWO); Fort McClellan Military Reservation

(old quarry) 33°42'N, 85°46'W, 30 Sep 1998, *J.B. Phipps and R. Lance 7774* (UWO). **Cherokee Co.:** 1 mi N of Pisgah Baptist Church Rd. on Co. Rd. 19, 7 May 1974, *T.A. Atkinson and Landers K.E. s.n.* (JSU). **Clarke Co.:** dry calcareous woods on summit of Salt Mountain, 15 May 1935, *R.M. Harper 3374* (A, GH); Jackson, 15 Apr 1852, *Dr. Henry s.n.* (ALU); Co. Rd. 15, S of Jackson, 31°26'N, 87°52'W, 1 Oct 2000, *J.B. Phipps and R. Lance 8193* (UWO). **Colbert Co.:** rocky hillside near Spring Valley, 20 Jul 1899, *H. Eggert s.n.* (A, MO). **Dallas Co.:** Pleasant Hill Rd. just before Richmond Rd., 27 Mar 1918, *R.S. Cocks 3342* (NO); Dallas Co. Rd. 407 between Shephardville and Elm Bluff near parking area on right, 32°11"N, 87°05'W, 14 Apr 1999, *J.B. Phipps 7898* (UWO); Elm Bluff area ca. 1.5 mi W of Shephardville on AL 41 32°11'N, 87°05'W, 14 Apr 1999, *J.B. Phipps 7880* (UWO); Elm Bluff area ca. 1.5 mi W of Shephardville on AL 41 32°11'N, 87°05'W, 14 Apr 1999, *J.B. Phipps 7881* (UWO). **Dallas Co.:** Rd. 407 between Shephardville and Elm Bluff near parking area on right 32°11'N, 87°05'W, 14 Apr 1999, *J.B. Phipps 7900* (UWO); Elm Bluff, W of Shephardville on Alabama River, 32°11'N, 87°05'W, 2 Oct 1998, *J.B. Phipps and R. Lance, 7790* (UWO); Elm Bluff, near Alabama River, 32°11'N, 87°06'W, 2 Oct 1998, *J.B. Phipps and R. Lance 7794* (UWO); Elm Bluff, W of Shephardville on Alabama River, 32°11'N, 87°05'W, 2 Oct 1998, *J.B Phipps and R. Lance 7788* (UWO). **De Kalb Co.:** Valley Head, 4 Oct 1916, *T.G. Harbison 12817* (NCU); Valley Head, Alabama, 2 May 1911, *T.G. Harbison 3062* (A); Valley Head, rocky slope of Lookout Mt., 25 Apr 1924, *T.G. Harbison 5906* (A, GH); Collinsville, 26 Sep 1899, *no collector* (A); sandstone out crop on rim of Little River Canyon, ca. 1 mi S of Co. Rd. 35 on Little River Canyon Rd., 15 Apr 1967, *R.C. Clark and K. Landers 11174* (UWO). **Etowah Co.:** on Colvin Mountain (reached by 431 to Cheeseburgh Rd.) 85°52.5'W, 33°68'N, 8 Apr 1998, *J.B. Phipps 7648* (UWO). **Franklin Co.:** State Rd. 247 at Cedar Creek Public Access Area (Cedar Creek Reservoir) 34°33'N, 87°58'W, 6 Oct 1988, *J.B. Phipps and R. Lance 7822* (UWO); AL 247 at Cedar Creek Public Access Area, 17 Apr 1999, *J.B. Phipps 7919* (UWO); W of Russellville, ca. 1/2 mi S of Co. Rd. 84, ca. 0.2 mi N of parking area for Cedar Creek Access Area, 200 ft upslope of E bank of Little Rock Creek, 10 Sep 1996, *A. Schotz s.n.* (UWO); State Rd. 247 at Cedar Creek Public Access Area (Cedar Creek Reservoir) 34°33'N, 87°58'W, 7 Oct 1998, *J.B. Phipps and R. Lance 7823* (UWO). **Greene Co.:** rich low woods, 1 mi E of Boligee, 9 May 1969, *J.L. Thomas 2058* (ALU). **Hale Co.:** Gallion, Alabama, 17 Apr 1915, *T.G. Harbison s.n.* (A); E side of AL 69, oak-hickory flatwoods ca. 3/8 mi S of Gallion, a little N of Marengo Co. line 32°29'N, 87°42'W, 12 April 1999, *J.B. Phipps 7867* (UWO); Gallion, 16 Apr 1915, *T.G. Harbison s.n.* (UNC); E side of AL 69 Oak-hickory flatwoods abt 3/8 mi S of Gallion, a little N of Marengo Co. line, 32°29'N, 87°42'W, 12 Apr 1999, *J.B. Phipps 7866* (UWO); 0.3 mi S of Railroad crossing, hwy 69 just S of Gallion Woods on E side of the road, 3 Oct 1988, *R. Lance s.n.* (UWO). **Jefferson Co.:** Gate City, near Birmingham, 28 Sep 1899, *C.D. Beadle B1397* (A, ALU, DOV, MO); near Gate City, 5 May 1900, *C.D. Beadle B2280* (ALU, MO); Red Mountain, Birmingham, 2 Oct 1916, *T.G. Harbison 4007* (A); Birmingham, 12 Sep 1911, *T.G. Harbison 674* (A); Birmingham, 10 Sep 1911, *T.G. Harbison 10674* (NCU). **Marion Co.:** Bear Creek, N of Hackleburg, 28 May 1972, *R. Kral 46812* (VDB). **Marengo Co.:** Co. Rd. 51, 2.5 km N of Co. Rd. 54 32°27'N, 87°40'W, 12 Apr 1999, *J.B. Phipps 7869* (UWO); Co. Rd. 51, 2.5 km N of Co. Rd. 54 32°27'N, 87°40'W, 12 Apr 1999, *J.B. Phipps 7868* (UWO); Allenville Rd., ca. 1.5 mi N of jct of hwy 54, on E side, 9 Apr 1999, *R. Lance s.n.* (UWO). **Montgomery Co.:** Black Belt, 19 Apr 1969, *J.C. Chitwood s.n.* (AUA); Caney Creek, SW of Montgomery, scrubby woodland N side of Hwy 80 86°23'W, 32°19'N, 6 Apr 1984, *J.B. Phipps and T.C. Wells 5312* (UWO); Caney Creek, SW of Montgomery, scrubby woodland N side of Hwy 80, 86°23'W, 32°19'N, 6 Apr 1984, *J.B. Phipps and T.C. Wells 5313* (UWO); Caney Creek, SW of Montgomery on US 80, 86°23'W, 32°19'N, 15 Oct 1984, *J.B. Phipps 5482* (UWO); US 80 at Caney Creek 32°19'N, 86°25'W, 24 Sep 1999, *R.J. O'Kennon and R. Lance 14450* (UWO); N side of US 80 at Caney Creek 32°19'N, 86°23'W, 12 Apr 1999, *J.B. Phipps 7877* (UWO); N side of US 80 at Caney Creek 32°19'N, 86°23'W, 12 Apr 1999, *J.B. Phipps 7876* (UWO); N side of US 80 at Caney Creek 32°19'N, 86°23'W, 12 Apr 1999, *J.B. Phipps 7875* (UWO); N side of US 80 at Caney Creek to the NE of Montgomery Airport 32°19'N, 86°23'W, 14 Apr 2000, *J.B. Phipps 8141* (UWO); Caney Creek, SW of Montgomery, N side of Hwy. 80, 86°23'W, 32°19'N, 6 Apr 1984, *J.B. Phipps and T.C. Wells 5314* (UWO); N side of US 80 at Caney Creek, to NE of Airport 32°19'N, 86°23"W, 10 Apr 1998, *J.B. Phipps 7673* (UWO); N side of US 80 at Caney Creek, 32°19'N, 86°23'W, 30 Sep 1998, *J.B. Phipps, and R. Lance 7775* (UWO); N side of US 80 at Caney Creek, 32°19'N, 86°23'W, 1 Oct 1998, *J.B. Phipps, and R. Lance 7779* (UWO). **Russell Co.:** roadside of Ala. 37, ca. 4 mi S of Marengo, 18 Jul 1967, *R.C. Clark 16135* (NCU). **Sumter Co.:** Fort Tombigbee, near Epes at Jones Bluff, off Hwy 11 (site owned by Univ. of W Alabama) NE of car-park 32°42'N, 88°07'W, 11 Apr 1998, *J.B. Phipps 7693* (UWO); Tombigbee, near Epes at Jones Bluff, off Hwy 11 (site owned by Univ. of W Alabama) NE of car-park 32°42'N, 88°07'W, 11 Apr 1998, *J.B. Phipps 7694* (UWO). **Winston Co.:** Ranger's Station in Winston Co., 24 May 1925, *W.W. Ashe s.n.* (NCU). **Unknown Co.:** Ranger's station on a hill, 28 May 1925, *W.W. Ashe s.n.* (NCU); near Nitrate plant, 14 May 1934, *C.J. Charlesworth and T.G. Harbison 716* (TENN).

ARKANSAS. Hot Springs Co.: De Rocne Quadrangle, NW 1/4 , Sec. 32, T 45, R 19 W, 18 Jul 1977, *J.L. Roberts 427* (UARK); 1.5 mi NW of De Roche off Co. Rd. 101, W of S.R. 128, 24 Apr 2006, *G. Yatskievych et al. 06-12* (MO, UWO).

GEORGIA. Bartow Co.: Pumpkinvine Creek, 9 May 1996, *J. Allison 9138* (GA); Pumpkinvine Creek, 28 Aug. 1996, *J. Allison 9431* (GA). **Dade Co.:** Fox Mountain Track up E side from S of Rising Fawn (at large run-off right)

34°44'N,85°32W, 19 Apr 2000, *J.B. Phipps et. al. 8153a* (UWO);Fox Mountain Track up E side from S of Rising Fawn (at large run-off right) 34°44'N,85°32'W, 19 Apr 2000, *J.B. Phipps et al. 8153* (UWO). **Floyd Co.:** cliffs along S side of Coosa River, 3mi SE of Rome, 30 Sep 1951, *W.H. Duncan 13323* (GA); cliffs of the Coosa River, 6 May 1899, *C.S. Sargent s.n.* (A, MO); cliffs of Coosa River near Rome, no date, *T.G. Harbison s.n.* (NCU); cliffs of Coosa River near Rome, 26 Jul 1899, *C.D. Beadle B764* (A); 4 mi below Rome, 6 May 1899, *no collector name C-O* (A); cliffs of Coosa River, Rome, 15 Sep 1899, *C.D. Beadle B1184* (A); cliffs of Coosa River, Rome, 20 Sep 1910, *T.G. Harbison 144* (A); cliffs of Coosa River near Rome, 5 May 1899, *W.M. Canby 43* (CM); cliffs of Coosa River near Rome, 5 May 1899, *W.M. Canby s.n.* (DOV); cliffs of Coosa River near Rome, 1899/9, *C.D. Beadle B1397* (DOV); Rome, 1882, *A.W. Chapman s.n.* (GH); McGee Bend Rd, off Ga. 100 (WSW of Rome), 19 Apr 2000, *J.B. Phipps et al. 8160* (UWO); McGee Bend Rd, off Ga. 100 (WSW of Rome), 19 Apr 2000, *J.B. Phipps et al. 8156* (UWO); above Coosa River, ca. 3 mi, SW Rome, 4 May 1980, *R. Kral 64929* (VDB). **Houston Co.:** Oaky Woods Wildlife Management Area, Green Violet Prairie, 14 Apr 2006, *J.B. Phipps and R. Lance 9064* (UWO); Oaky Woods Wildlife Management Area, Green Violet Prairie, 25 Sep 2005, *R. Lance 2930, 2931, 2932* (UWO). **Walker Co.:** poorly marked trail on Pigeon Mountain from SSW of Marsh Crossing to Bluebird Gap 34°42.5'N, 85°21'W, 18 Apr 2000, *J.B. Phipps et. al. 8151* (UWO); Pigeon Mt. near summit, W side of slope at limestone outcroppings, NE of pocket Brance, N 34° 42.187', W 085° 21.998', 25 May 2000, *R. Lance 00 019* (UWO). **Unknown Co.:** mountains of Georgia, *no collector* (MO); Georgia, May 1895, *A.W. Chapman s.n.* (DOV).

LOUISIANA. Caldwell Parish: Ouachita River, ca. 1.25 mi E of Copenhagen, Sec 13, 92°97'W, 32°01'N, 20 Apr 1984, *F.M. Givens 3604* (LSU); gorges E of Copenhagen and La. 849 and W of Ouachita River Sec. B, 10 May 1983, *R.D. Thomas and B. Hess 83427* (NLU); clay pine hills along Ouachita River, 1 mi E of Copenhagen Sec. 11,12,13 on moist woods, 17 Mar 1973, *P. Marx and P. Jones 422* (NLU); gorges NE of Copenhagen, NE corner of Sec. 14 clay soil, mixed hardwoods forest, 20 May 1973, *R.D Thomas, P. Marx et al. 3439 & 1042* (NLU); along ridges just W of Ouachita River and E of Copenhagen and La. 849, 20 Apr 1979, *R.D. Thomas and Botany 103 Class 6339* (NLU); hills near small creek S of dirt road and E of Copenhagen, Sec. 13, 26 Jun 1973, *R.D. Thomas, P Marx and Bot 313 Class 35892* (NLU); gorges along Creek 1.5 mi E of Copenhagen, 8 Jun 1973, *R.D. Thomas and P. Marx 35294 & 1323* (NLU); open clay pasture NE of Copenhagen NE corner of Sec. 14, 2 Jun 1973, *P Marx, P. Jones and D. Lawson 1193* (NLU); gorges E of Copenhagen and La. 849 and W of Ouachita River, Section 13, 3 Aug 1982, *R.D. Thomas, T. Dorris et al. 82032* (NLU); beside small creek W of Ouachita River and E of Copenhagen Sec. 13, 6 Aug 1975, *R.D. Thomas and Bot. 313 class 45887* (NLU); beside small creek W of Ouachita River and E of Copenhagen Sec. 13, 6 Aug 1975, *R.D Thomas and Bot. 313 class 45911* (NLU); 1.5 mi E of Copenhagen, 8 Jun 1973, *R.D. Thomas and P. Marx 35294* (UWO); 1.5 mi E of Copenhagen, 8 Jun 1973, *Thomas, R.D. and P. Marx 1323* (UWO); E of Copenhagen and La. 849 S of Columbia and W of Ouachita River, sec. 13, T12 N, R4E, 4 Apr 1987, *R.D. Thomas 99232* (UWO; E of Copenhagen and La. 849 S of Columbia and W of Ouachita River, sec. 13, T12 N, R4E, 28 Mar 1987, *R.D. Thomas and Bot. 103 class 99203* (UWO).

MISSISSIPPI. Chickasaw Co.: ca. 6.5 mi SSE of Houston, Kilgore Hills, the E edge of the county just W of Clay Co. on rural rd, T15S, R3E, S12, the NE/4 of SE/4, 12 Jan 1997, *J.R. Macdonald et al. 10267* (UWO). **Clay Co.:** Kilgore Hills, ca. 5.5mi NNE Montpelier, NW4 S7, 15 Apr 1981, *S. McDaniel and R. Haynes 24955* (FSU); ca. 6.5 mi SSE of Houston, Kilgore Hills, just inside county from Chickasaw Co. on rural rd, T15S, R4E, S7 the NW/4 of the SW/4, 12 Apr 1997, *J.R. MacDonald et al. 10266* (UWO); Co. Rd. 83 at trash dump, Kilgore Hills area NE of Sparta, 33°48'N, 88°56'W, 30 Sep 2000, *J.B. Phipps, and R. Lance 8190* (UWO). **Lee Co.:** tn ckets, clay and limestone hills near Verona, 22 May 1931, *E.J. Palmer 39021* (MO). **Monroe Co.:** S of Amory, ESE of jct. US 45, MS 41, S of 278 at Sandhills Rd., 33°58'N, 88°34'W, 6 Oct 1998, *J.B. Phipps and R. Lance 7820* (UWO). **Newton Co.:** Eureka Church Cemetery at jct. of Gordy Rd. and Moffet Rd. 32°15'12"N, 89°15'17"W, 2 Sep 2001, *R. Lance 2147* (MO); Eureka Church Prairie jct. of Gordy Rd. and Moffet Rd. 32°15'N, 89°15'W, 25 Sep 1999, *J.B. Phipps, R.J. O'Kennon and R. Lance s.n.* (UWO); Eureka Church Prairie jct. of Gordy Rd. and Moffet Rd., 32°15'N, 89°15'W, 12 Apr 2000, *J.B. Phipps 8124* (UWO); Gordy Rd. W of MS 505, NW quadrant, N of Moffet Rd., 32°15'N, 89°16'W, 16 Apr 1999, *J.B. Phipps 7911* (UWO); Gordy Rd. W of MS 505, NW quadrant, N of Moffet Rd., 32°15'N, 89°16'W, 16 Apr 1999, *J.B. Phipps 7910* (UWO); Gordy Rd. W of MS 505, NW quadrant, N of Moffet Rd., 32°15'N, 89°16'W,16 Apr 1999, *J.B. Phipps 7912* (UWO); intersection of Gordy Rd. and Moffett Rd. NW quadrant, 1 km W of MS 505., 32°15'N, 89°16'W, 11 Apr 1999, *J.B. Phipps 7862* (UWO); dirt rd. parallel to MS 505 and 2/3 mi W of it, opposite Nance Hill, 32°15'N, 89°16'W, 4 Oct 1998, *J.B. Phipps and R. Lance 7809* (UWO); dirt rd. parallel to MS 505 and 2/3 mi W of it, opposite Nance Hill, 32°15'N, 89°16'W, 4 Oct 1998, *J.B. Phipps and R. Lance 7808* (UWO); dirt rd. parallel to MS 505 and 2/3 mi W of it, opposite Nance Hil., 32°15'N, 89°16'W, 4 Oct 1998, *J.B. Phipps and R. Lance 7807* (UWO); dirt rd. parallel to MS 505 and 2/3 mi W of it, opposite Nance Hill., 32°15'N, 89°16'W, 4 Oct 1998, *J.B. Phipps and R. Lance 7810* (UWO). **Scott Co.:** NW side of Sherman Hill on 551F (gated) 31°17'N, 89°22'W, 25 Sep 1999, *J.B. Phipps et. al. 8080* (UWO); W of Forest, S of US 80, gated Forest Rd. 537, 32°19.5'N, 89°33'W, 12 Apr 2000, *J.B. Phipps 8121* (UWO); NE side of Sherman Hill, just S of

Durand Oak Prairie, Forest Rd. 551F ca. 3.5 mi in 31°1"N, 89°23'W, 13 Apr 2000, *J.B. Phipps and J. Herring 8133* (UWO); E side of Sherman Hill, edge of Forest Rd. 551F, cutover at ca. 0.5 mi in 32°17'N, 89°23'W, 13 Apr 2000, *J.B. Phipps and J. Herring 8131* (UWO); NE side of Sherman Hill, just S of Durand Oak Prairie, Forest Rd. 551F, ca. 3.5 mi in, 32°17'N, 89°23'W, 13 Apr 2000, *J.B. Phipps and J. Herring 8132* (UWO); E side of Sherman Hill, edge of Forest Rd. 551F, 31°17'N, 89°21'W, 13 Apr 2000, *J.B. Phipps and J. Herring 8129* (UWO); E side of Sherman Hill, edge of Forest Rd. 551F, 31°17'N, 89°21'W, 13 Apr 2000, *J.B. Phipps and J. Herring 8128* (UWO); E side of Sherman Hill, edge of Forest Rd. 551F, 31°17'N, 89°21'W, 13 Apr 2000, *J.B. Phipps and J. Herring 8127* (UWO); W of Forest, S of US 80, gated Forest Rd. 537, 0–200 m inside barrier, 32°19.5'N, 89°33'W, 12 Apr 2000, *J.B. Phipps 8120* (UWO); W of Forest, S of US 80, closed dirt Forest Rd. 537, 32°19.5'N, 89°33'W, 26 Sep 1999, *J.B. Phipps 8087* (UWO); Sherman Hill ca. 6.5 mi SW of Lake, 32°17'N, 89°24'W, 4 Oct 1998, *J.B. Phipps 7812* (UWO). **Tishomingo Co.:** Tishomingo City, Mississippi, 8 May 1915, *T.G. Harbison s.n.* (A); Tishomingo, Mississippi, 8 May 1915, *T.G. Harbison 12014* (NCU). **Webster Co.:** NE of Maben, C.R. 188, 33°34'N, 88°04'W, 27 Sep 1999, *J.B. Phipps, R.J. O'Kennon, and R. Lance 8105* (UWO); ca. 2.0 mi N of Maben (T20N R12E S20 SW4 NW4) T.E. Smith property, 22 Jun 1985, *T.E. Smith 1396* (UWO); off MS 15 N of Maben (Oktibbeha Co.), first dirt rd. going SE, 33°33'N, 89°04'W, 4 Oct 1998, *J.B Phipps and R. Lance 7815* (UWO); off MS 15 N of Maben (Oktibbeha Co.), first dirt rd. going SE, 33°33'N, 89°04'W, 4 Oct 1998, *J.B Phipps and R. Lance 7816* (UWO); ca. 2.0 mi N of Maben (T.E. Smith property), T20N R12E, 520 SW4 NW4, 2 May 1985, *T.E. Smith et al. 1260* (UWO).

NORTH CAROLINA. Macon Co.: Chapel Hill, Emilyme Gap, Sep 1912, *T.G. Harbison s.n.* (NCU); Cullasaja River, Aug 1912, *W.W. Ashe s.n.* (NCU). **Unknown Co.:** Western NC, 23 May 1901, *W.W. Ashe s.n.* (NCU).

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Book Notice

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Pyrimidine and Purine Biosynthesis and Degradation in Plants
Phytochrome Structure and Signaling Mechanisms
Microtubule Dynamics and Organization in the Plant Cortical Array

MORPHOMETRIC ANALYSIS OF AN *AMELANCHIER* (ROSACEAE: MALOIDEAE) COMPLEX ON THE DELMARVA PENINSULA (DELAWARE, MARYLAND AND EASTERN VIRGINIA) RESOLVES THE TAXONOMIC IDENTITIES OF *AMELANCHIER OBOVALIS* AND *A. CANADENSIS*

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ABSTRACT

Amelanchier obovalis and *A. canadensis* (Rosaceae: Maloideae) are similar taxa with overlapping geographical ranges on the Atlantic Coastal Plain of the United States. Conflicting circumscriptions, polyploidy, hybridization, and agamospermy may have contributed to the taxonomic confusion in these species. In this study I perform a morphometric examination of these two species on the Coastal Plain of Delaware, Maryland and the eastern shore of Virginia—collectively called the Delmarva Peninsula. I developed a dataset of eleven flowering, fruiting and vegetative characters taken from marked individuals. A second dataset contains six minimally correlated characters that were obtainable from the type specimen of *Amelanchier obovalis*. I use Principal Components Analysis (PCA) to summarize phenetic similarities and dissimilarities between individuals and agglomerative, hierarchical Cluster Analysis to aid in visualization of morphological groups. Selection of groups (putative taxa) to inform a testable group model was performed iteratively using concordance in phenetic methods (PCA and Clustering) and inferential descriptive statistics. Analysis supported a four-group model for which I found a significant overall multivariate effect (Pillai's Trace, $F = 7.29$, $P > F < 0.0001$) using Multivariate Analysis of Variance (MANOVA). Two well-supported groups (1 & 4) corresponded to *Amelanchier obovalis* and *Amelanchier canadensis*. The remainders of the sample are intermediate between *Amelanchier obovalis* and *Amelanchier canadensis* and may be the product of recurrent hybridization between these taxa. Lack of clearly delimited morphological character space and apparent ecological and genetic exchangeability in these taxa suggests the taxonomic rank of variety under the earliest combination in *Amelanchier*, e.g., *Amelanchier canadensis* var. *canadensis* and *Amelanchier canadensis* var. *obovalis* as originally proposed by Michaux (1803). I present a taxonomic treatment and historical analysis of the species taxonomy and a dichotomous key to the varieties.

RESUMEN

Amelanchier obovalis y *A. canadensis* (Rosaceae: Maloideae) son taxa similares con áreas geográficas solapadas en la llanura costera atlántica de los Estados Unidos. Las circumscripciones conflictivas, poliploidía, hibridación, y agamospermia pueden haber contribuido a la confusión taxonómica en estas especies. En este estudio realizo un examen morfométrico de estas dos especies en la llanura costera de Delaware, Maryland y costa este de Virginia—llamados colectivamente Península de Delmarva. He desarrollado un conjunto de datos de once caracteres de flores, frutos y vegetativos tomados de individuos marcados. Un segundo conjunto de datos contiene seis caracteres mínimamente correlacionados que se obtuvieron del espécimen tipo de *Amelanchier obovalis*. Utilizo el Análisis Componentes Principales (PCA) para resumir las similitudes fenéticas y disimilitudes entre individuos y un Análisis de Clusters jerarquizado para ayudar en la visualización de grupos morfológicos. La selección de grupos (taxa putativos) para informar de un modelo de grupo comprobable se realizó iterativamente usando la concordancia en los métodos fenéticos (PCA y Clustering) y estadística descriptiva inferencial. El análisis da un modelo de cuatro grupos para el que encontré un efecto multivariante general significativo (Pillai's Trace, $F = 7.29$, $P > F < 0.0001$) usando Análisis de Varianza Multivariante (MANOVA). Dos grupos muy claros (1 & 4) correspondieron a *Amelanchier obovalis* y *Amelanchier canadensis*. Los restos de la muestra son intermedios

entre *Amelanchier obovalis* y *Amelanchier canadensis* y pueden ser el producto de hibridación recurrente entre estos taxa. La falta un espacio de caracteres morfológicos claramente delimitados y aparente intercambio ecológico y genético en estos taxa sugiere el rango de variedad bajo la combinación más antigua en *Amelanchier*, e.g., *Amelanchier canadensis* var. *canadensis* y *Amelanchier canadensis* var. *obovalis* como fue propuesto originalmente por Michaux (1803). Presento un tratamiento taxonómico y análisis histórico de la taxonomía de las especies y una clave dicótoma para las variedades.

INTRODUCTION

Amelanchier Medic. (Rosaceae: Maloideae) is comprised of deciduous small trees and shrubs of the North Temperate Zone (Phipps et al. 1990). *Amelanchier* flowers are pentamerous, radially symmetrical and protogynous (Robinson 1982; Campbell et al. 1991) arranged as inflorescences of simple racemes (except in *A. bartraminana*). *Amelanchier* fruits are globose, berry-like pomes that attract a wide variety of frugivorous dispersers (Robinson 1986). The leaves of *Amelanchier*, and of the subfamily Maloideae in general, vary greatly in size, shape and dentation, and mature foliage on short shoots is often very different from those on juvenile (e.g., new sucker growth) or long shoots (Robertson et al. 1992). The total enumeration of taxa varies among authors. For example, in the northeastern United States, Landry (1975) recognized six species; Fernald (1950a) includes 19 species but Gleason and Cronquist (1991) only nine species. Synonymy within *Amelanchier* is formidable, reflecting uncertainty surrounding taxonomic concepts of species and infraspecific taxa (see Fernald 1941; 1946). Reproductive biology of *Amelanchier* is characterized by polyploidy, agamospermy and extensive hybridization between most eastern North American species (Wiegand 1912; 1935; Jones 1946; Cruise 1964; Campbell et al. 1987; Weber and Campbell 1989; Campbell et al. 1991; Dickinson and Campbell 1991; Campbell and Wright 1996; Campbell et al. 1997b; Campbell 1999). Recent research has revealed several complex taxonomic issues arising from mating system versatility in the genus including the presence of persistent, morphologically distinctive hybrids, e.g. *Amelanchier* x *neglecta* (Weber and Campbell 1989; Campbell and Wright 1996), microspecies derived from intraspecific hybridization followed by agamospermy, e.g., *Amelanchier "rubra"* (Dibble et al. 1998) as well as wide morphological variation among populations of single species (Cruise 1964; Campbell et al. 1997a). Reproductive versatility in *Amelanchier*, i.e., the combination of vegetative spread, interspecific hybridization and formation of agamic complexes has contributed to their phenotypic diversity and ecological success, particularly in early successional environments (Wiegand 1912, 1935; Cruise 1964; Robertson 1974; Campbell et al 1991; Campbell 1999).

Despite the abundance and ecological importance of *Amelanchier* in the southeastern United States this genus remains poorly studied. This may be due, in part, to the limited field work that the primary authors of the genus (e.g., K.M. Wiegand, G.N. Jones, M.L. Fernald) performed in the southern states but probably more persistently by the difficulty in gathering adequate material for study, and the limited usefulness of herbarium material, including some type specimens, (Wiegand 1912; Nielsen 1939; Fernald 1946; Jones 1946; Cruise 1964).

In a long-term study (1999-present), mainly of the stoloniferous members of *Amelanchier*, the most problematic species for confident identification in the field and herbarium have been *Amelanchier canadensis* (L.) Medic. and *Amelanchier obovalis* (Michx.) Ashe. *Amelanchier canadensis* and *A. obovalis* occur along the east coast of North America with overlapping ranges in the southeastern United States. Herbarium sheets labeled as these species often have multiple annotations and the opinion expressed often seems cor-

related with the general habitat types written on the label and notes on plant habit or height noted by the collector and not their morphological characteristics (C. Frye, pers. obs.).

Three species in addition to *Amelanchier obovalis* and *A. canadensis* are listed in floras (Tatnall 1946, Brown and Brown 1980) specifically covering the geographic region known as the Delmarva Peninsula (Fig. 1), which is comprised of eastern Maryland, Delaware and eastern Virginia (hereafter referred to as the study area).

Amelanchier arborea (Michx. f.) Fernald is a species of dry, upland forests that is excluded in this analysis. *Amelanchier intermedia* Spach, is restricted to the Piedmont and Mountain physiographic provinces (Wiegand 1920) and was not considered here. *Amelanchier stolonifera* Wieg. is cited by Tatnall (1946) from the Piedmont physiographic province in Delaware (not included in the study area). *Amelanchier canadensis* (L.) Medic. var. *subintegra* Fernald (Fernald 1950b) has been observed by the author in the study area but no specimen corresponding to this taxon occurred in the sample.

Shrubs and small trees that key to *Amelanchier canadensis* and *A. obovalis* are widespread and common in the study area but many characters purported to separate the species in taxonomic keys appeared highly variable, temporal, or were the subject of disagreements among authors. Characters such as plant habit (stoloniferous and colony forming versus clumped and multi-stemmed), plant height, and ovary pubescence that are often used in major couplets to distinguish these species I found were difficult to objectively determine. For example, nearly all individuals in the study vigorously sucker but under certain conditions such as mowing and burning form low, shrubby colonies with apparent vegetative spread. Long observation (1999-present) of *Amelanchier* in the study area suggested the presence of at least two coherent taxa; however, several morphologies could not be identified with existing taxonomic keys (Wiegand 1912; Fernald 1950a; Radford et al. 1968; Gleason & Cronquist 1991). Taxonomic complexity in the study area may reflect the presence of numerous distinctive microspecies produced by hybridization events followed by asexual seed production and/or cryptic hybridization involving a number of agamosperms that would be difficult to detect using morphological characters present at a single phenological stage.

This study aims to determine whether *Amelanchier* occurring on the Delmarva Peninsula exists as a complex of intergrading, minimally separable phenotypes or contains two or more well-defined taxa that are significantly different from each other in morphology, ecology or both. In order to examine morphological complexity and evaluate the various treatments of *Amelanchier canadensis* and *A. obovalis* I developed two datasets of morphometric characters. The first dataset comprised a "full" set of flowering, fruiting and vegetative characters taken from marked individuals (Full dataset). The Full dataset was used to explore multivariate relationships between individuals, reduce dimensionality and select taxonomically informative characters. The second dataset comprises a reduced set of characters that includes only those characters present on the type specimen of *Amelanchier obovalis* (Type dataset). The Type dataset is analyzed to determine the taxonomic identity of *Amelanchier obovalis*. A similar analysis using the type of *Amelanchier canadensis* was not possible given the few taxonomically informative characters present.

Due to the complex classification history of *Amelanchier canadensis* and *A. obovalis* I defined groups for analysis *a posteriori*, without taxonomic classification so as to avoid confounding *a priori* taxonomic identity with the partitioning of morphological variation. I use a combination of Cluster Analysis and Principal Components Analysis (PCA)

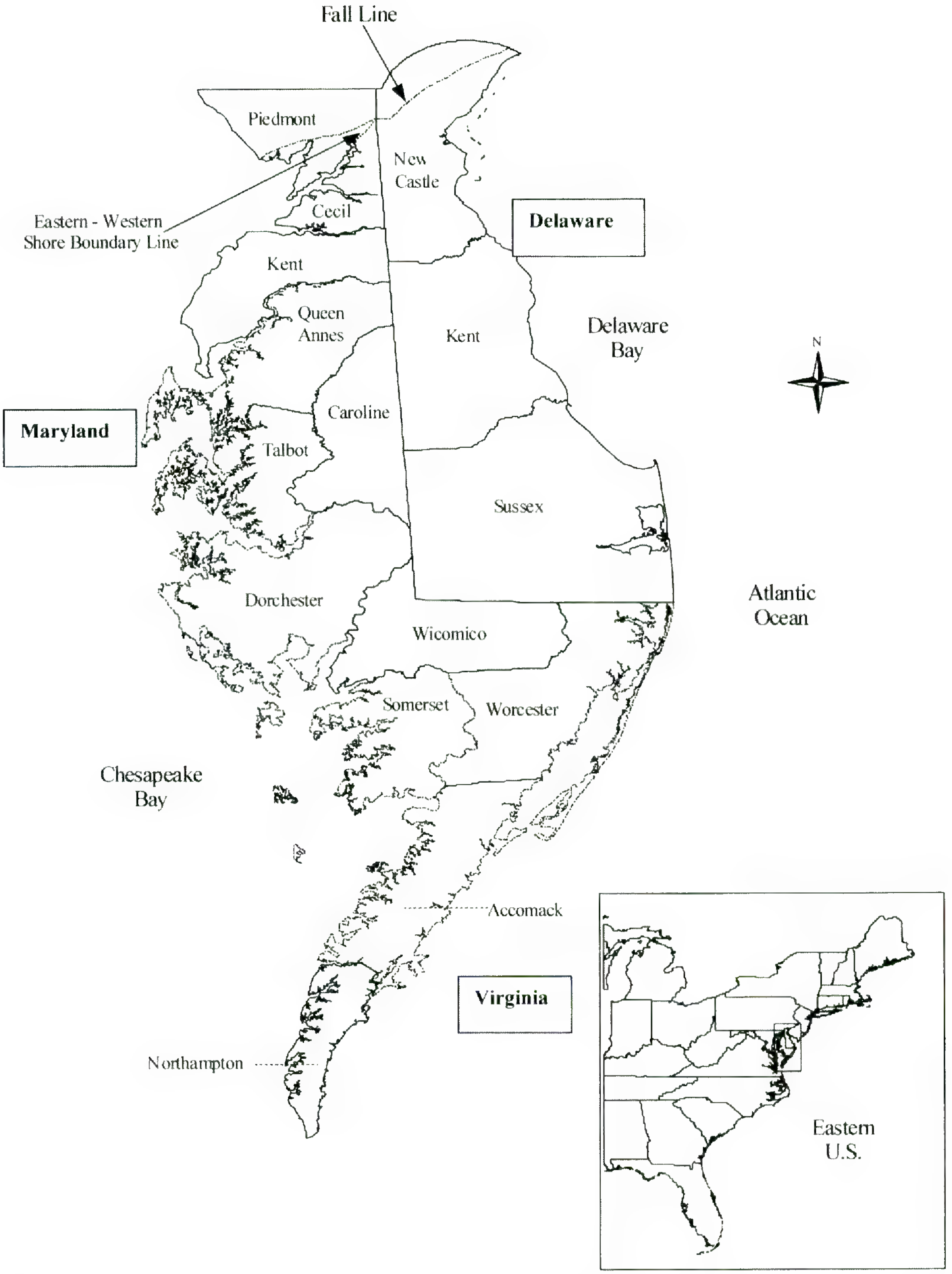


FIG. 1. Geographical location of the study area. The Delmarva Peninsula of the eastern United States comprising Delaware (New Castle, Kent and Sussex Counties), eastern Maryland and eastern Virginia (Accomack and Northhampton Counties).

to delimit groups (putative taxa) and Multivariate Analysis of Variance (MANOVA) to test the best-supported group model. Multivariate analysis of morphological data has been used to resolve species complexes in *Amelanchier* (Dibble et al. 1998), classify taxa within groups defined *a priori* (Saarela et al. 2003; Leonard et al. 2005) and to resolve difficulties caused by morphological overlap in infraspecific taxa (Whang et al. 2002).

The taxonomic treatment and arguments developed herein are presented in a historical context beginning with André Michaux's *Flora Boreali-Americana* (1803) and relying heavily on the landmark treatment of *Amelanchier* by Karl Wiegand (1912).

METHODS

Study Site.—The Delmarva Peninsula comprises the eastern shore of Maryland, all of Delaware (New Castle, Kent and Sussex Counties) and the eastern shore of Virginia (Accomack and Northhampton Counties) bounded on the west by the Chesapeake Bay and the Susquehanna River and on the east by the Atlantic Ocean (Fig. 1). The Delmarva Peninsula lies south of the fall-line, a term used to describe the boundary between the Piedmont Province and the Atlantic Coastal Plain and falls entirely within the Outer Coastal Plain Mixed Forest Province of Bailey (1995). Elevations on the peninsula are mostly less than 20 m ASL and are underlain by relatively young Tertiary and Quaternary sediments of uniformly low relief (Schmidt 1993). It is mostly within the Oak-Pine forest region, with the northernmost counties transitional to the Oak-Chestnut region (Braun 1950). Significant habitat features include extensive fresh and salt tidal marshes, blackwater river swamps, barrier islands and Delmarva Bays (seasonal ponds). The climate of Delmarva is moderated by the Delaware Bay, Chesapeake Bay and the Atlantic Ocean and is characterized as having cool winters and warm, humid summers.

Character Selection and Sample Size Determination.—I used data from two characters: (1) length of the flowering inflorescence [hereafter abbreviated as Flinfllen] and (2) length of the lowest pedicel on the flowering raceme [hereafter Flpedlen] as a model for determining sample size requirements in the field study. These two characters have been used by many authors (Ashe 1903; Jones 1946; Fernald 1941, 1950; Robertson 1974; Wiegand 1912, 1920) to describe *Amelanchier obovalis* and *A. canadensis* and were readily obtainable from herbarium sheets. I took measurements of Flinfllen and Flpedlen from 54 accessions of both species from herbarium specimens borrowed from CM, DOV, FLAS, GA, MARY, NA, NCU, PH, US, USCH, VPI (acronyms follow Holmgren et al. 1990) and of personal collections from Delaware, Maryland, North Carolina and Virginia. Flpedlen had the lowest dispersion of scores ($\bar{u}$ = 11.88 mm, σ = 5.46 mm, N = 119) and the ratio of the standard deviation to the mean, expressed as a percentage, (Coefficient of Variation) was 46%. Iterative sample size analysis (Sokal and Rohlf 1968, p. 247) converged on a sample size > 53 that would be sufficient for an 80% certainty of determining a 25% difference between means at the 5% significance level by Analysis of Variance. For the field study I chose an additional thirteen characters that I determined might be informative in describing variation in the complex: (1) the proportion of the length of the flowering inflorescence comprised by the lowest flowering pedicel [Flped_flinfl], (2) ovary pubescence during flowering [Flovpub], (3) flowering sepal position [Flsepos], (4) length of the fruiting inflorescence [Frinfllen], (5) length of the lowest pedicel on the fruiting raceme [Frpedlen], (6) the proportion of the length of the fruiting inflorescence comprised by the lowest fruiting pedicel [Frped_frinfl], (7) ovary pubescence on the developing fruit [Frovpub], (8) sepal position on the developing fruit [Frsepos], (9) petal length [Petlen],

(10) petal width [Petwid], (11) the ratio of petal length/petal width [Petl_wratio], (12) the leaf length/width ratio [Lfl_wratio] and (13) the ratio of the widest point of the leaf relative to total leaf length [Lfwidpt]. Table 1 provides a complete list of characters, their descriptions and measurements. The means of five replicates per character on each individual were calculated and used in subsequent analyses for all quantitative characters. Of the total 15 characters, four were multi-state, categorical variables: flowering and fruiting sepal position [Flsepos, Frsepos] and flowering and fruiting ovary pubescence [Flovpub, Frovpub]; these characters are not included in analysis of variance but were collected for descriptive purposes and as a preliminary sample for future analysis.

Sampling.—During the late winter and early spring I marked 75 individuals of *Amelanchier* with permanent tags on a north-south transect from Cecil County, Maryland (39 32' 38" N) to Northhampton County, Virginia (37 08' 45" N). Additionally, I included a sample from within the core range of *Amelanchier obovalis* (Bladen County, North Carolina) matching the description of *Amelanchier obovalis* by Fernald (1950a) and Radford et al. (1968). I did not attempt to stratify the sample among disturbance levels, although in order to examine any correlations with disturbance and to avoid ecological bias in selecting the sample I marked individuals in both natural habitats (interior of swamp forests, hummocks along fresh-tidal rivers, pine flatwoods) and disturbed habitats (roadside verges, clearcuts, and powerlines). I returned to each marked individual during peak flower and mid-fruiting stages. I defined the peak flowering period as the stage when all flowers on the raceme had expanded and mature petals could be easily removed from the upper flowers. I defined the early fruiting stage as the period when the ovary on the developing fruit had swollen but the fruit was still green or just coloring and mature leaves were available.

Additional effort was made to examine variation in elongation of the lower pedicels over time, a character noted by several authors (Ashe 1903; Wiegand 1912; Fernald 1941; Jones 1946) and one that I thought might be informative for understanding the various taxonomic concepts of *Amelanchier obovalis and A. canadensis*. This additional character is not used in the multivariate analysis. I examined the difference between mean length of the lowest pedicel at peak flower and at mid-fruit by analysis of variance. Inflorescence and pedicel measurements were taken in the field, all other measurements were taken in the lab. All measurements utilized a digital caliper and an ocular micrometer scaled to tenths of a millimeter. Vouchers of flowering and fruiting material were collected from marked individuals at each site; these are deposited at the Maryland Department of Natural Resources Herbarium (Tawes), Annapolis, MD. Sampling began on 18 April 2005 and continued through 26 May 2005. Flowering, fruiting and leaf measurements were successfully gathered for 61 individuals.

Quantitative Morphological Analyses.—My overall objective for the analysis of quantitative morphological characters is to test the null hypothesis of no significantly distinguishable groups of individuals. To test the null hypothesis I looked for discrete clusters using Principal Components Analysis (PCA) based on the correlation matrix of eleven (Full dataset) and six (Type dataset) quantitative characters standardized by log transformation. I also used the Full dataset to reduce the dimensions of the dataset by eliminating highly correlated characters (Pearson's r >0.7). Proportion of variance explained by each axis was compared with that expected under a broken-stick model (Jackson 1993). I plotted the first principal component against the second to graphically portray any relationships among individuals. Additionally, I created a second matrix from an

TABLE 1. List of the 15 character acronyms, their descriptions and measurement. All measurements taken to the nearest tenth of a millimeter.

Character acronym	Description and Measurement
Flinfllen	Length of the flowering inflorescence at peak flower. Measured from the base of the distal-most flower on the raceme to point of insertion on the stem.
Flpedlen	Length of the lowest pedicel on the flowering raceme at peak flower. Measured from the base of the ovary to point of insertion on the raceme.
Flped_flinfl	Proportion of the length the flowering raceme comprised by the lowest pedicel.
Flovpub	Ovary pubescence on the terminal flower of the flowering raceme scored from 1 (glabrous) to 4 (densely tomentose).
Flsepos	Sepal position on the terminal flower of the flowering raceme scored along a scale from 1 (erect) to 4 (tightly reflexed) in comparison to an imaginary transverse plane through the ovary.
Frinfllen	Length of the fruiting inflorescence. Measured from the base of the distal-most fruit on the raceme to point of insertion on the stem.
Frpedlen	Length of the lowest pedicel on the fruiting raceme at mid-fruit. Measured from the base of the ovary to point of insertion on the raceme.
Frped_frinfl	Proportion of the length of the fruiting raceme comprised by the lowest pedicel.
Frovpub	Ovary pubescence on the terminal fruit of the fruiting raceme scored along a scale from 1 (glabrous) to 4 (densely tomentose).
Frsepos	Sepal position on the terminal fruit of the fruiting raceme scored along a scale from 1 (erect) to 4 (tightly reflexed) in comparison to an imaginary transverse plane through the ovary.
Petlen	Length of mature, expanded petals measured from distal-most point to insertion on the hypanthium.
Petwid	Width of mature expanded petals measured at the widest point.
Petl_wratio	Ratio of petal length/petal width.
Lfl_wratio	Ratio of leaf length/leaf width.
Lfwidpt	Ratio of the widest point along the leaf axis (measured from base)/total leaf length.

agglomerative, hierarchical Cluster Analysis using Euclidean distance and Ward's method of linkage (McCune & Grace 2002). This second matrix was used as an overlay on the PCA scatterplot to assist in visualizing groups. PCA and Clustering were performed on Pcord version 4.14 (McCune & Mefford 1999).

A separate objective was to determine the identity (group membership) of the type specimen of *Amelanchier obovalis* in multivariate character space. I performed both PCA and Clustering based on the correlation matrix of six quantitative characters derived from analysis of the Full dataset and that were also obtainable from the type specimen: Petlen, Flinfllen, Flpedlen, Flped_flinfl, Lfl_wratio, and Lfwidpt. The Type dataset was organized into a group by character matrix and exported to SAS version 9.1 (SAS Institute, Cary, NC, USA) for Multivariate Analysis of Variance (MANOVA, GLM procedure). MANOVA tests for an overall multivariate effect of the group model and performs pairwise comparisons between character means (mean vectors) for all groups for each character. Approximate univariate normality of morphometric characters within each group was assessed by inspection of frequency histograms, accepting normality with skewness < 1 (McCune & Grace 2002). MANOVA is robust to multivariate non-normality and Levene's test was used to ascertain homogeneity of variances within each group. MANOVA is used to test the null hypothesis of no significant differences between the mean vectors of each group.

Assessment of Taxonomic Rank.—I utilize the concepts of genetic and ecological exchangeability introduced by Crandall et al. (2000) to assess population distinctiveness and extend that method to assessing taxonomic rank. Species populations are genetically exchangeable if there is evidence of ample gene flow between them. Ecological exchangeability is demonstrated if individuals can be moved between populations and can occupy the same ecological niche. Exchangeability is viewed from both recent and historical perspectives, e.g., two taxa may currently experience gene flow due to breakdown of intrinsic or extrinsic barriers via anthropogenic causes but the populations may have historically experienced (e.g., presettlement) little gene flow.

RESULTS

Full Dataset.—Eigenvalues for the first two axes, representing 56% of the total variation, exceeded their broken-stick values and were chosen for interpretation (Table 2). PCA-1 comprises > 37% of the variance in the dataset. Five morphological characters ordinate individuals along PCA-1. These are, in descending order in the loading matrix (Table 3): Flpedlen, Frpedlen, Frinfllen, Flinfllen and Petlen. PCA-1 is thus a size axis. PCA-2 comprises > 19% of the variance in the dataset. Five morphological characters ordinate individuals along PCA-2. These are, in descending order in the loading matrix (Table 3): Flped_flinfl, Frped_frinfl, Lfl_wratio, Flinfllen and Frinfllen. PCA-2 is chiefly a shape axis. The characters most highly correlated with both PCA axes are also very highly correlated with each other, in particular, flowering and fruiting stages of the inflorescence are redundant (Table 4). Flowering characters were selected for the final matrix.

Type Dataset.—Six characters were used in the analysis of the Type dataset: Petlen, Flinfllen, Flpedlen, Flped_flinfl, Lfl_Wratio and Lfwidpt. These six quantitative characters were obtainable from the type specimen of *Amelanchier obovalis* and serendipitously mirrored the set of minimally correlated characters derived from analysis of the Full dataset with the exception of Flpedlen (r = 0.708), which I maintained because of its use as an informative character in most treatments. The dendrogram produced by Cluster Analysis (Fig. 2) is scaled by an objective function that measures the loss of information at each step; as groups are fused the amount of information decreases until all groups are fused and no information remains (McCune & Grace 2002). In the iterative process, five and higher order groups were composed of single (outlier) individuals and selection of three groups combined groups 2 and 3 into a single membership cluster. I chose to overlay a four-group cluster on the PCA as this appeared to be the maximum number of well-supported groups (e.g., long branches of the dendrogram) and corresponded to my field observations of the number of putative morphological forms prior to sampling and roughly to the different habitat types that were sampled (e.g., tidal and nontidal swamps, low Pine woodlands, and sand ridges). The PCA scatterplot with Cluster overlay (Fig. 3) shows a single distinct cluster at the far left of PCA-1 and central to PCA-2. The eigenvalues for the first two principal components, representing >65% of the total variation, were selected for interpretation; however, only the second axis exceeded its broken-stick value (Table 5). PCA-1 comprises > 39% of the variance in this dataset. Three morphological characters ordinate individuals along PCA-1. These are, in descending order in the loading matrix (Table 6): Flpedlen, Flinfllen and Petlen. PCA-1 is a size axis clearly separating group 1 (positive affinities) and group 4 (negative affinities) but with overlap between groups 2 and 3 at the origin. PCA-2 comprises > 26% of the variance in the dataset. Three characters ordinate individuals along PCA-2. These are, in

TABLE 2. **Full dataset**. Eigenvalues, percent variance extracted and broken-stick comparison of four Principal Component axes with eigenvalues > 1.

Axis	Eigenvalue	Percent of variance	Cumulative Percent	Broken-stick Eigenvalue
1	4.106	37.325	37.325	3.020
2	2.112	19.204	56.529	2.020
3	1.482	13.470	69.999	1.520
4	1.199	10.902	80.901	1.187

TABLE 3. **Full dataset.** Principal components loading matrix of the correlations between eleven morphological characters and component scores (eigenvectors).The five highest correlations with the eigenvector are in bold type.

Character	Eigenvector	
	1	2
Petlen	**-0.3267**	0.0632
Petwid	-0.2567	0.0249
Petl_wratio	-0.0921	0.0471
Flinfllen	**-0.3826**	**-0.3641**
Flpedlen	**-0.4620**	0.0131
Flpedl_flinfl	-0.2524	**0.4800**
LfL_wratio	0.0045	**-0.4525**
Lfwidpt	0.0434	0.3073
Frinfllen	**-0.3906**	**-0.3242**
Frpedlen	**-0.4433**	0.0426
Frpedl_frinfl	-0.2107	**0.4732**

descending order in the loading matrix (Table 6): Lf l_wratio, Flped_f linf l and Lf widpt. PCA-2 is a shape axis that most clearly separates group 3 (positive affinities) from group 2 (negative affinities).

The type specimen of *Amelanchier obovalis* is nested near the center of group 1 outside of the range of variation (along PCA-1) in other groups (see Fig. 3). Descriptive statistical analysis of the four-group model, calculating the means, standard deviations and 90% confidence intervals of morphological characters most highly correlated with PCA-1 and PCA-2 provide some morphological coherence of the groups with strong positive or negative affinities along the principal component axes (Table 7). Group 1 (triangles) consists of individuals (on PCA-1) having short petals (6.8 ± 0.9mm), short flowering inflorescences (28.7 ± 0.9mm), and short lower pedicels (7.9 ± 1.3 mm). On the second PCA axis group 1 consists of individuals with leaves averaging 1.8 times as long as wide (1.79 ± 0.22) that are widest above the midpoint (0.548 ± 0.037) and have more or less cylindrical inflorescences (0.283 ± 0.053). Group 4 (stars) consists of individuals (on PCA-1) having long petals (8.8 ± 1.2mm), long flowering inflorescences (47.8 ± 3.9mm) and long lower pedicels (15.8 ± 1.7mm). On the second PCA axis group 4 consists of individuals with leaves averaging 1.8 times as long as wide (1.80 ± 0.18), that are widest near the midpoint (0.519 ± 0.034), and have spreading inflorescences (0.335 ± 0.042). Group 2

TABLE 4. **Full dataset**. Cross-products matrix of Pearson's Correlation Coefficients (r) for eleven morphological characters. Values of r 0.7 (r ounded) are in bold type.

	Petlen	Petwid	Petl_wratio	Flinfllen	Flpedlen	Flpedl_flinfl	Lfl_wratio	Lfwidpt	Frinfllen	Frpedlen	Frpedl_frinfl
Petlen	1	**0.669**	0.396	0.368	0.497	0.327	0.005	0.137	0.385	0.398	0.156
Petwid	-	1	-0.410	0.328	0.356	0.163	-0.049	0.164	0.314	0.326	0.118
Petl_wratio	-	-	1	0.062	0.185	0.202	0.043	-0.057	0.104	0.107	0.057
Flinfllen	-	-	-	1	**0.778**	-0.018	0.229	-0.271	**0.839**	**0.652**	-0.021
Flpedlen	-	-	-	-	1	0.612	-0.024	-0.117	**0.708**	**0.794**	0.372
Flpedl_flinfl	-	-	-	-	-	1	-0.329	0.146	0.058	0.434	0.616
Lfl_wratio	-	-	-	-	-	-	1	-0.168	0.192	-0.039	-0.311
Lfwidpt	-	-	-	-	-	-	-	1	-0.179	-0.094	0.073
Frinfllen		-	-	-	-	-		-	1	**0.759**	-0.042
Frpedlen	-	-	-	-	-	-	-	-	-	1	0.602
Frpedl_frinfl	-	-	-				-	-		-	1

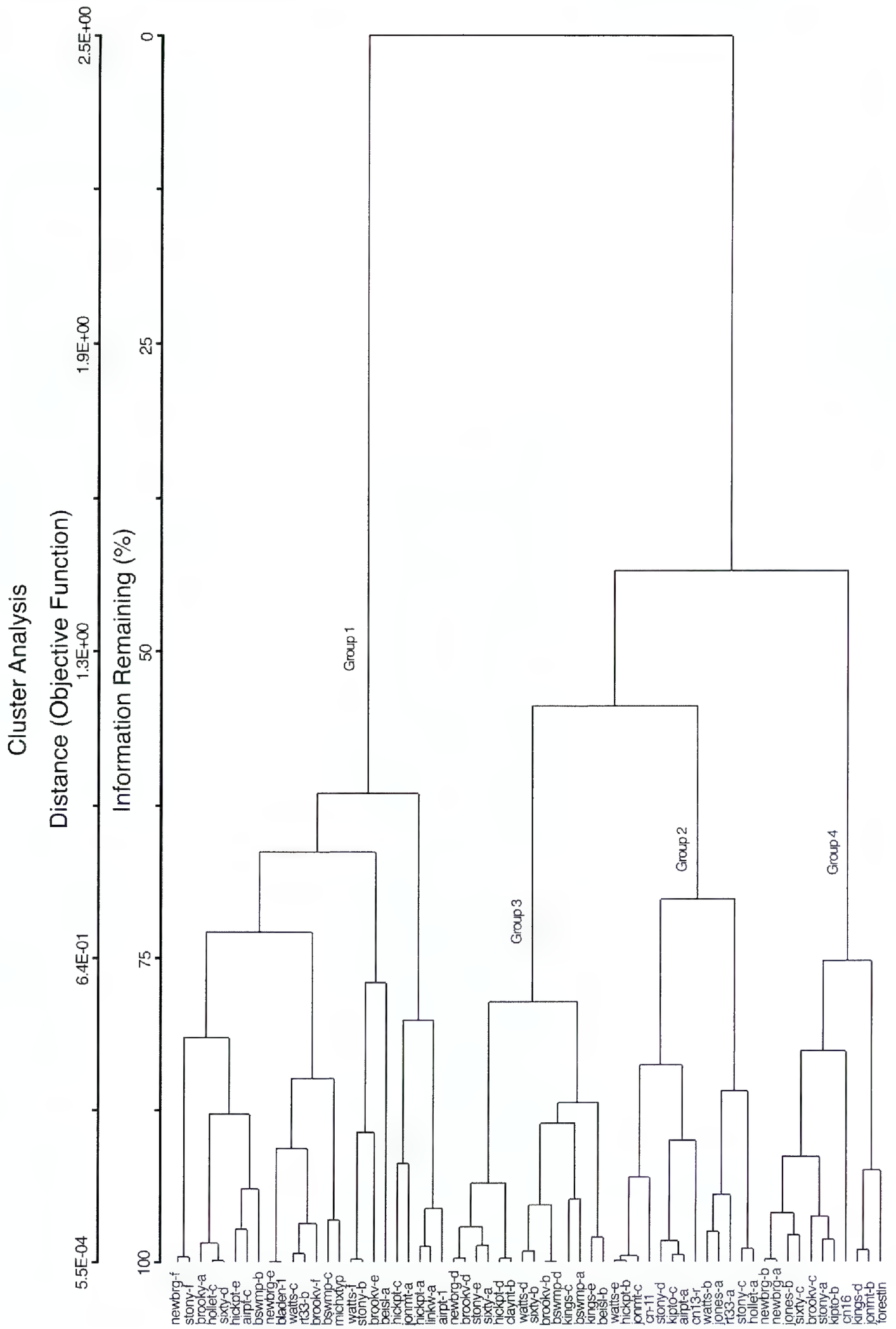


FIG. 2. Dendrogram produced by Cluster Analysis showing pruning points and group assignments of 62 individuals.

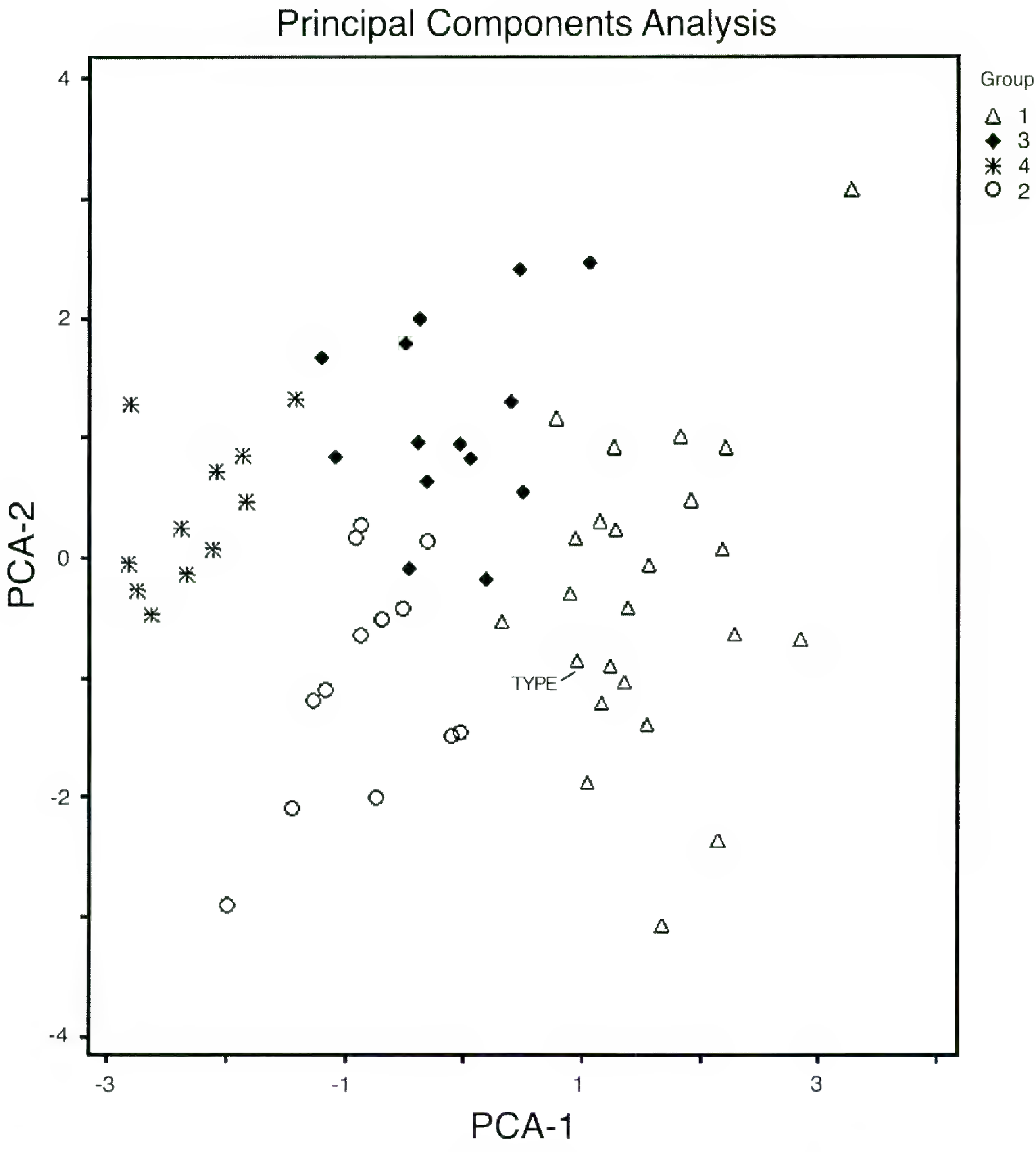


FIG. 3. PCA scatterplot with Cluster overlay. Symbols denote group membership: triangles = group 1, circles = group 2, diamonds = group 3, stars = group 4. Type specimen of *Amelanchier obovalis* indicated.

(circles) consists of individuals (on PCA-1) having intermediate petal lengths (7.7 ± 0.8 mm), flowering inflorescences (35.1 ± 4.6) and lower pedicels (12.6 ± 1.7mm). On the second PCA axis group 2 consists of individuals with leaves averaging 1.7 times as long as wide (1.67 ± 0.14) that are widest above the midpoint (0.547 ± 0.057) and have widely spreading flowering inflorescences (0.363 ± 0.043). Group three (diamonds) consists of individuals (on PCA-1) having intermediate length petals (7.3 ± 0.9mm), long flowering inflorescences (39.6 ± 3.0mm) with short lower pedicels (10.8 ± 1.1mm). On the second PCA axis group 3 consists of individuals with leaves averaging 1.9 times as long as wide (1.87 ± 0.17), that are widest at the midpoint (0.503 ± 0.029), and have cylindrical flowering inflorescences (0.272 ± 0.026).

TABLE 5. **Type dataset**. Eigenvalues, percent variance extracted and broken-stick comparison of two Principal Component axes with eigenvalues > 1.

Axis	Eigenvalue	Percent of variance	Cumulative Percent	Broken-stick Eigenvalue
1	2.345	39.082	39.082	2.450
2	1.575	26.243	65.325	1.450

TABLE 6. **Type dataset**. Principal Components loading matrix of the correlations between six morphological characters and component scores (eigenvectors). The three highest correlations with the eigenvector are in bold type.

Character	Eigenvector	
	1	2
Petlen	**-0.4524**	-0.1036
Flinfllen	**-0.4994**	0.4079
Flpedlen	**-0.6326**	0.0032
Flpedl_flinfl	-0.3720	**-0.5164**
LfL_wratio	0.0144	**0.5610**
Lfwidpt	0.0842	**-0.4914**

Multivariate Analysis of Variance.—There is a significant overall multivariate effect of the four-group model (Table 8) and significant F ratios were found for five of the six quantitative characters (Table 9). Pair-wise comparisons between all groups (Table 9) determined significant differences between all pairwise group mean vectors for Flinfllen and five of six comparisons for Flpedlen. Petlen was significant for 4 of 6 group comparisons, Flped_flinfl was significant in 4 of 6 group comparisons, and Lfwidpt was significant for 2 of 6 group comparisons. Differences between group mean vectors for LfL_Wratio were not significant. Group 4 contains the most distinctive individuals, as expressed by all pairwise comparisons of mean vectors for Petlen, Flinfllen, and Flpedlen and two of three pairwise comparisons for Flped_flinfl. Group 1 is also distinctive as expressed by all group comparisons for Flinfllen and Flpedlen, 2 of 3 pairwise comparisons for Petlen, 2 of 3 pairwise comparisons for Flped_flinfl, and 1 of 3 pairwise comparisons for Lfwidpt. Group 2 is significant in all pairwise comparisons for Flinfllen, 2 of 3 comparisons of Flpedlen, 2 of 3 pairwise comparisons for Petlen, 2 of 3 pairwise comparisons for Flped_flinfl, and 1 of 3 pairwise comparisons for Lfwidpt. Group 3 is significant in all pairwise comparisons for Flinfllen, 2 of 3 comparisons of Flpedlen, but only 1 of 3 pairwise comparisons for Petlen, 2 of 3 comparisons for Flped_flinfl and 2 of 3 comparisons for Lfwidpt.

The presence of a large sample of individuals with intermediate phenotypes suggests ample gene flow (genetic exchangeability) between the groups. Ecological exchangeability is demonstrated by the occurrence of morphologically distinct individuals occurring within the same habitat type.

Taxonomic Usefulness of the Elongation of the Lowest Pedicel.—There is significant variation among groups in the elongation of the lowest pedicel from peak flowering to mid-fruiting as determined by Analysis of Variance. The difference between the mean

TABLE 7. Descriptive statistics of six characters most highly correlated with the principal components (PCA-1 and PCA-2) under a four-group model. Columns under Group labels are: N = number of individuals in group, means ± standard deviations, (ranges), [minimum; maximum], {90% Confidence Intervals}. All measurements reflect raw (untransformed) scores.

Character	Group 1	Group 2	Group 3	Group 4
	N = 24	N = 13	N = 14	N = 11
Petlen	6.8 ± 0.9 (3.0) [5.6; 8.6] {6.5 —7.1}	7.7 ± 0.8 (3.5) [5.9; 9.4] {7.3—8.1}	7.3 ± 0.9 (3.0) [5.8; 8.8] {6.9—7.7}	8.8 ± 1.2 (4.0) [6.5; 10.5] {8.1—9.5}
Flinfllen	28.7 ± 0.9 (17.3) [18.7; 36.0] {27.1—30.3}	35.1 ± 4.6 (14.4) [28.4; 42.8] {32.8—37.4}	39.6 ± 3.0 (8.8) [35.0; 43.8] {38.2—41.0}	47.8 ± 3.9 (10.6) [42.2; 52.8] {45.7—49.9}
Flpedlen	7.9 ± 1.3 (5.7) [5.6: 11.3] {7.4—8.4}	12.6 ± 1.7 (5.6) [9.6; 15.2] {11.8—13.4}	10.8 ± 1.1 (3.4) [9.3; 12.7] {10.3—11.3}	15.8 ± 1.7 (5.2) [13.2; 18.4] {14.9—16.7}
Flpedl_flinfl	0.283 ± 0.053 (0.238) [0.167; 0.405] {0.264—0.302}	0.363 ± 0.043 (0.163) [0.293; 0.456] {0.342—0.384}	0.272 ± 0.026 (0.108) [0.212; 0.320] {0.260—0.284}	0.355 ± 0.042 (0.123) [0.273; 0.396] {0.332—0.378}
LfL_wratio	1.79 ± 0.22 (0.70) [1.47; 2.17] {1.71—1.87}	1.67 ± 0.14 (0.45) [1.41; 1.86] {1.60 -1.74}	1.88 ± 0.17 (0.58) [1.64; 2.22] {1.80—1.96}	1.80 ± 0.18 (0.59) [1.56; 2.15] {1.70—1.90}
Lfwidpt	0.548 ± 0.037 (0.145) [0.471; 0.616] {0.535—0.561}	0.547 ± 0.057 (0.171) [0.441; 0.612] {0.522—0.572}	0.503 ± 0.029 (0.114) [0.468; 0.582] {0.490—0.516}	0.519 ± 0.034 (0.097) [0.473; 0.570] {0.500-0.538}

flowering pedicel length and mean fruiting length are not significant in group 4 ($P = 0.15$, $F_{\alpha .05 [1,20]} = 2.23$, $F_{critical} = 4.35$) indicating that the inflorescence elongates very little from peak flower to mid-fruit. Significant differences between mean flowering and mean fruiting pedicel length were found in the other three groups. Group 1 has the largest F ratio ($P < .0001$, $F_{\alpha .05 [1,44]} = 26.39$, $F_{critical} = 4.06$) indicating that the lowest pedicel elongates significantly from peak flower to fruit. Group 2 and group 3 also show significant differences in this character (Group 2: $P = .001$, $F_{\alpha .05 [1,24]} = 13.53$, $F_{critical} = 4.26$; Group 3: $P = .0006$, $F_{\alpha .05 [1,26]} = 15.17$, $F_{critical} = 4.23$).

DISCUSSION

Multivariate analysis of morphological characters distinguishes four groups of specimens within the *Amelanchier* complex on the Delmarva Peninsula. Group 1 contains shrubby or multi-stemmed *Amelanchier* with short and rather fat petals, short, cylindrical flowering and fruiting inflorescences with short lower pedicels. This group of specimens is referable to *Amelanchier obovalis*; the type specimen nests within this group outside of the range of variation of other groups. This group may be more clearly visually defined by

TABLE 8. MANOVA test criteria and F approximations for the hypothesis of no overall effect of the four-group model.

Statistic	Value	F Value	Num DF	Den DF	Pr . F
Wilk's Lambda	0.04823940	14.12	18	150.39	, .0001
Pillai's Trace	1.47957567	7.29	18	165	, .0001
Hotelling-Lawley	9.83905376	27.18	18	100.15	, .0001

TABLE 9. Univariate F values (GLM procedure) and P > F for six informative characters and pairwise group comparisons of character means using Tukey's Studentized Range (HSD). Critical value of Studentized Range = 3.74. * = Comparisons significant at α =.05, df =58; ns = not significant. Grp1 = *A. obovalis*; Grp4 =*A. canadensis*.

Character	F ratio for Character	P . F	Group Comparison (Tukey)	Difference b/w means	Confidence Limits 95%	
Flinfllen	61.59	0.0001	grp4-grp2	13.19	8.82—17.56	*
			grp4-grp3	8.25	3.95—12.55	*
			grp4-grp1	19.10	15.21—22.98	*
			grp2-grp3	4.98	0.827—9.05	*
			grp2-grp1	5.91	2.32—9.58	*
			grp3-grp1	10.85	7.26—14.43	*
Flpedlen	68.86	, 0.0001	grp4-grp2	3.70	2.01—5.39	*
			grp4-grp3	5.05	3.39—6.72	*
			grp4-grp1	7.93	6.42—9.43	*
			grp2-grp3	1.35	-0.24—2.94	ns
			grp2 grp1	4.22	2.80—5.64	*
			grp3-grp1	2.87	1.48—4.26	*
Flped_flinfl	10.16	, 0.0001	grp4-grp2	0.019	-0.032—0.070	ns
			grp4-grp3	0.063	0.012—0.113	*
			grp4-grp1	0.053	0.007—0.098	*
			grp2-grp3	0.081	0.033—0.129	*
			grp2 grp1	0.071	0.028—0.114	*
			grp3-grp1	0.010	-0.032—0.052	ns
Lfl_wratio	2.01	0.1228	grp4-grp2	0.104	-0.106—0.314	ns
			grp4 grp3	0.079	-0.127—0.285	ns
			grp4-grp1	0.016	-0.171—0.203	ns
			grp2-grp3	0.183	-0.015—0.380	ns
			grp2-grp1	0.088	-0.089—0.264	ns
			grp3-grp1	0.094	-0.078—0.267	ns
Lfwidpt	5.99	0.0013	grp4-grp2	0.031	-0.009—0.072	ns
			grp4-grp-3	0.017	-0.023—0.057	ns
			grp4 grp1	0.030	-0.006—0.066	ns
			grp2-grp3	0.048	0.010—0.086	*
			grp2-grp1	0.002	-0.033—0.036	ns
			grp3-grp1	0.046	0.013—0.080	*
Petlen	12.13	0.0001	grp4 grp2	1.11	0.079—2.15	*
			grp4-grp3	1.53	0.510—2.55	*
			grp4-grp1	2.06	1.14—2.98	*
			grp2-grp3	0.41	-0.559—1.39	ns
			grp2-grp1	0.94	0.073—1.81	*
			grp3-grp1	0.53	-0.320—1.38	ns

eliminating outliers; however, eliminating these individuals in the PCA does not change group membership and these specimens do appear to represent natural variation within the group. One individual classified in group 1 (upper right corner of Fig. 3) deviates from the morphological group defined here by an extremely narrow cylindrical inflorescence. This individual may best be recognized as a separate entity; however, no other similar individual or specimen was located during sampling. Individuals forming group 1 (*A. obovalis*) were collected chiefly from sandy woodlands and barrens but did occur on hummocks along tidal creeks and thicket margins around non-tidal wetlands in disturbed and in nearly pristine habitats. Individuals are typically low and shrubby but may grow to several meters in absence of disturbance; this was ideally illustrated by single, apparently clonal individuals with stems that were inside and outside of a roadside-mowing regime.

Group 4 corresponds to a group of tall, arborescent or multi-stemmed *Amelanchier* with large petals and long lower pedicels forming long, widely spreading flowering and fruiting inflorescences. This group of specimens is referable to *Amelanchier canadensis*, matching as well as can be expected the type specimen and at least part of the historical circumscriptions. Individuals in group 4 (*A. canadensis*) were collected from both tidal and non-tidal swamp forests and were easily distinguished in the field. This species occurs sympatrically with *Amelanchier obovalis* in some habitats.

Group 1 and group 4 correspond to known taxonomic entities (*Amelanchier obovalis* and *A. canadensis* respectively) but group 2 and group 3, despite the statistical significance of several pairwise comparisons of character mean vectors in the MANOVA could not be assigned to distinctive forms such as might arise as microspecies. I hypothesize that group 2 and group 3 are members of an agamic complex derived from hybridization between *Amelanchier canadensis* and *A. obovalis*. Evidence of apomixis has been demonstrated in *Amelanchier canadensis* (Campbell et al. 1987) but not in *A. obovalis*. However, evidence to support this hypothesis may be drawn from my statistical analysis and observation. First, both *Amelanchier canadensis* and *A. obovalis* (as clear entities) were observed to occur within the same habitat patch in the study area and were observed to have overlapping phenologies, which increase the probabilities that natural hybridization occurs. Second, the means of important classification characters in group 2 and group 3 (with 90% confidence intervals) consistently occupy ranges intermediate between *Amelanchier canadensis* and *A. obovalis* (Table 7). Finally, the members of groups 2 and 3 appear morphologically heterogeneous and do not correspond to the four putative morphological forms that I noted in the field prior to sampling or to a particular habitat type. My field observations were that one form was referable to *Amelanchier obovalis* (group 1), a second to *Amelanchier canadensis* (group 4), a third group comprised the pubescent-ovary forms within group 1 and the fourth, an early flowering *Amelanchier* with small petals on hummocks along tidal creeks I now believe are consistent with *Amelanchier obovalis*.

Additionally, the discrimination of multivariate character space held by group 2 versus group 3 is uncertain. Group 2 and 3 separate nearly at the origin of PCA-2 (Fig. 3) and the character most highly correlated with this second axis (r = .704) is Lfl_Wratio, a character that fails statistical significance tests between groups in Analysis of Variance (see Table 9). Further, comparison of mean vectors of two important characters (Flpedlen and Petlen) between group 2 and group 3 are not significant (Table 9). Finally, the iterations of Cluster Analysis join group 2 and 3 in a three-group model and then collapse into group 4 (*A. canadensis*) in a two-group model. If I accept more variation in *Amelanchier canadensis* and consider a two-group model composed of *Amelanchier*

obovalis and a new group containing all the members of groups 2, 3 and 4 then my performance in keying vouchers would certainly improve but accepting this variation comes with a heuristic cost in that I obscure the only spatially distinctive cluster resulting from PCA. Given the well-documented propensity for hybridization and the formation of agamic complexes in *Amelanchier*, the most reasonable assumption is that individuals within group 2 and group 3 do constitute intermediate forms due to incomplete reproductive isolation between *Amelanchier canadensis* and *A. obovalis*.

I conclude that the multivariate character space occupied by *Amelanchier obovalis* exhibits significant phenetic dissimilarities with the other groups as expressed by its distinctiveness in Cluster Analysis (e.g., the long branch before joining) and by statistical significance of the majorities of group comparisons of character mean vectors for Flinfllen, Flpedlen, Petlen, and Flped_flinfl. The discreteness of multivariate character space occupied by *Amelanchier canadensis* can be determined both visually (occurrence of a distinct cluster in the PCA) but also by the statistical significance of the majorities of group comparisons of character mean vectors for Flinfllen, Flpedlen, Petlen and Flped_flinfl. However, the presence of numerous intermediate specimens violates most commonly accepted taxonomic conceptions of species status. Subspecies as a taxonomic rank is poorly defined in the literature of taxonomic botany and is used more or less interchangeably with variety (McDade 1995; Nesom and Lipscomb 2005). Wiegand (1912), Fernald (1950a) and Jones (1946) assigned the rank of variety to those distinctive forms of *Amelanchier* that occupied a particular geographical area and/or had a habitat preference slightly different than that typical of the species. Campbell and Dickinson (1990) concluded that nonconcordance between morphological and breeding units in Maloid apomicts rendered the biological species concept inappropriate and that a morphospecies concept may be necessary to deal with evolutionary complexity in the Maloideae. In this study I found no well-defined geographical or ecological separation between the taxa. However, I must also consider that the high frequency of intermediate forms found in the study area may reflect the long disturbance history of the Delmarva Peninsula and this disturbance history is responsible for recent, but perhaps not historical, genetic and ecological exchangeability (Crandall et al. 2000). That the frequency of disturbance often correlates with the number of hybrids and 'perplexing forms' has been the subject of repeated observation and much discussion among authors since Wiegand (1912). The study populations of *Amelanchier* fall under Crandall's et al. (2000) case of "anthropogenic convergence on demographic exchangeability" where we continue to treat the populations as distinct units but not as distinct species. Both taxa are distinctive enough morphologically and intermediate forms may not occur with such frequency in other regions. In the taxonomic treatment below, I utilize the taxonomic concept of "variety" defined as the primary taxonomic level below species (International Code of Botanical Nomenclature, 4.1).

TAXONOMIC TREATMENT

Amelanchier canadensis (L.) Medic. var **obovalis** Michx. TYPE: *Mespilus canadensis* var. *obovalis* Michx., Fl. Bor. Amer. 1:291. 1803. *Amelanchier obovalis* (Michx.) Ashe, Bot. Gaz. 35:434. 1903, in part. *Amelanchier obovalis* (Michx.) Ashe, M.L. Fernald in Rhodora 43:566. 1941, in part. *Amelanchier oblongifolia* (Torr. & A. Gray) Roemer, K.M. Wiegand in Rhodora 14:147–150. 1912, in part. *Amelanchier canadensis* ssp. *obovalis*, P. Landry, Bull. Soc. Bot. Fr. 122:248. 1975.

Amelanchier obovalis is a rather enigmatic species with a long history of circumscription problems. André Michaux (1803) described *Mespilus canadensis* var *obovalis* from

"carolina inferiore" (lower Carolina) as "humilior; folius oblongiscule obovalibus" (low with oblong obovate leaves) and "arbriss de deux pieds haut" (a shrub about two feet tall). The Michaux specimen (P) is very well preserved having several stems with inflorescences and petals intact and a single stem with (apparently mature) expanded leaves. A century later Ashe (1903) created a new combination, *Amelanchier obovalis* (Michx.) Ashe describing a shrub of "swamps and loose soils" 9–15 dm tall or a small tree to four meters tall with flowering inflorescences 3–5 cm long, the lowest pedicels 3–9 mm but becoming elongate (2–3 cm) in fruit. Wiegand (1912), probably the most influential of *Amelanchier* taxonomists, includes *Amelanchier obovalis* (Michx.) Ashe under his "fastigiate not stoloniferous" *Amelanchier oblongifolia* (Torr. & A. Gray) Roemer. stating that it "seemed to be this species" but it is not clear that Wiegand ever saw any of Ashe's collections from the southeastern United States. Wiegand (1912) described his *A. oblongifolia* as a shrub with slender upright stems in rather dense fastigiate clumps with inflorescences 2.5–6 cm long, the lowest pedicels 8–18 mm long but scarcely longer in fruit. M.L. Fernald (1941), after several field seasons exploring the Pine Barrens of southeastern Virginia, disagreed with Ashe's description of *Amelanchier obovalis*, particularly regarding plant height, and subsequently ignored his treatment, describing *Amelanchier obovalis* (Michx.) Ashe as a "dwarf and stoloniferous" shrub with flowering inflorescences 1–2.5 cm long with lower pedicels lengthening only to 3–8 mm. Fernald (1950a) distinguished the species in his key chiefly by plant habit in a major couplet: "stoloniferous or surculose loosely colonial shrubs" 0.2–2 M. high (*A. obovalis*); versus "fastigiate coarse and tall shrubs or arborescent" (*A. canadensis*). Jones (1946) closely followed Fernald's (1941) treatment of *Amelanchier obovalis* as "low shrubs, surculose, forming loose colonies" but with flowering inflorescences 1–3 cm long with lower pedicels 1–3 mm, becoming 3–8(11–14 mm) long in fruit. Landry (1975) describes *Amelanchier obovalis* as a subspecies of *A. canadensis* with the major difference between the two subspecies being the general size of floral inflorescences and (very vaguely) the length of the lowest pedicels with *Amelanchier canadensis* ssp. *canadensis* having "rather large" flower clusters and lower pedicels at least 6 mm long versus clusters of flowers small and lower pedicels more than 6 mm long (*A. canadensis* ssp. *obovalis*).

The members of Group 1 (*Amelanchier canadensis var. obovalis*) are both low shrubs with apparent vegetative spread and tall, slender, multi-stemmed shrubs that occurred in a variety of habitats including hummocks on margins of tidal creeks and rivers, sandy pine forests and barrens, roadsides and under powerlines. In both flowering and fruiting stages the lowest pedicels were the shortest in the dataset and although they did elongate in fruit the extremes that Ashe (1903) suggested (10–20 mm) were not observed. I suspect that Ashe, perhaps due to finding very similar phenotypes in a variety of habitats or by witnessing the same complex as analyzed herein conflated the characteristics of both taxa. M.L. Fernald (1941), on the other hand, accepted only the extreme shrubby forms of the species and somewhat idiosyncratically noted that the taller species was probably *Amelanchier austromontana*, a species that Ashe (1918) described from the Southern Appalachian Mountains and not the southern Coastal Plain.

Amelanchier canadensis (L.) Medic.var. **canadensis.** TYPE: *Mespilus canadensis* L., Sp. Pl. 1:498. 1753.

Amelanchier oblongifolia (Torr. & A. Gray) Roemer, K. Wiegand in Rhodora 14:147–150. 1912, in part.
Amelanchier obovalis (Michx.) Ashe, Bot. Gaz. 35:434. 1903, in part.

Amelanchier canadensis (L.) Medic. is the earliest combination in *Amelanchier*; the type

specimen (LINN) from "habitat in Virginia, Canada" contains a single stem with five leaves and the remnants of a fruiting inflorescence with three fruit. The type is of limited usefulness as the characters used by major authors of the genus to separate *Amelanchier canadensis* from *A. obovalis*, e.g. plant habit, petal length, flowering inflorescence length and lowest pedicel length are absent. Wiegand's (1912) circumscription of *Amelanchier oblongifolia* appears to include both *Amelanchier canadensis* and *A. obovalis* as the ranges of character measurements are inclusive of both taxa. Similarly, Ashe's (1903) circumscription of *Amelanchier obovalis* appears to include characteristics of both species. It is very difficult to generalize but overall most authors treat *Amelanchier canadensis* as a fastigate shrub forming alder-like clumps having larger petals, and larger inflorescences than the low, shrubby and stoloniferous *Amelanchier canadensis* var. *obovalis*.

The members of Group 4 (*Amelanchier canadensis* var. *canadensis*) comprise a group of tall, fastigiate shrubs and small trees having the largest petal dimensions, very long flowering and fruiting inflorescences with long lower pedicels forming widely spreading inflorescences. This variety is easily distinguished in the field however numerous individuals with characters intermediate between the two varieties are present in the study area. Individuals of *Amelanchier canadensis* var. *canadensis* were located, mostly, in natural habitats associated with tidal and non-tidal wetlands, however, there appears to be little habitat specificity and these individuals occurred often in close proximity to var. *obovalis*. Wiegand's notion that the pedicels of his *Amelanchier oblongifolia* are "scarcely longer in fruit" appears consistent with the results of Analysis of Variance comparing lowest pedicel lengths in flowering versus fruiting material; although, it is apparent that Wiegand also conflated the characteristics of both taxa, perhaps because he was unfamiliar with the more southern forms constituting *Amelanchier obovalis*.

KEY

The following key to *Amelanchier canadensis* includes the other common species occurring in the study area, *Amelanchier arborea* (Michx. f.) Fernald. In keying *Amelanchier* one should realize that many specimens would not key confidently without observations (collections) made throughout the growing season. Those specimens with intermediate characters are likely part of the species complex and so should be simply identified as 'comparing favorably' with one variety or the other. The twenty-four members of group 1 (*A. c. obovalis*) provide the mean and range (one standard deviation) of characters that should be used to identify this species and the eleven members of group 4 (*A. c. canadensis*) provide the mean and range of the same morphological characters.

Specimens with entire leaves from the southeastern Coastal Plain may constitute var. *subintegra* Fernald but this putative taxon is not included in the key as its evaluation was not within the scope of this manuscript.

Sepals in flower and in fruit tightly recurved and appressed to the ovary, leaves subcordate at base, acute to acuminate at the apex and coarsely serrate. Arborescent species of upland woods
_____ **Amelanchier arborea**

Sepals in flower and in fruit not tightly appressed to ovary, leaves rounded at base, rounded to broadly rounded at apex and finely serrate. Tall shrubs with slender stems or dwarf shrubs with evident vegetative spread, chiefly of swamps and barrens at low elevations __ **Amelanchier canadensis**

Petals (5.9–)6.8(–7.7) mm long and (2.6–)3.1(–3.6) mm wide, inflorescences at peak flower (27.8–)28.7(–29.6) mm, elongating in fruit to (27.2–)32.1(–37.1) mm, lowest pedicels (flowering) (6.6–)7.9(–9.2) mm, elongating in fruit to (8.2–)11.0(–13.8) mm. Inflorescences usually cylindrical, the lowest pedicel averaging 28% of the total inflorescence length at flowering, and 35% percent

in fruit. Leaves on older branches chiefly obovate, the widest point occurring at 51–58 percent of the total leaf length. Sepals usually erect in flower, but often spreading during maturation of the ovary. Ovary summit usually glabrous but a variable amount of pubescence occurs in some forms (typically in dry, well-drained habitats). Plants are typically short and shrubby but may grow to several meters in the absence of disturbance _____ var. **obovalis**

Petals (7.6–)8.8(–11) mm long and (3.1–)3.7(–4.3) mm wide, inflorescences at peak flower (43.9–)47.8(–51.7) mm, elongating in fruit to (43.2–)48.2 (–53.2) mm, lowest pedicels (flowering) 15.8(14.1)–(17.5) mm, elongating in fruit to (15.1–)17.5 (–19.9) mm. Inflorescences using widely spreading, the lowest pedicel averaging 36% of the total inflorescence length at flowering, and 38% in fruit. Leaves on older branches chiefly broadly elliptical or occasionally oblong, the widest point at 49–55% of the total leaf length. Sepals usually spreading to reflexed in flower and in fruit. Ovary summit glabrous. Plants are typically multi stemmed with tall slender branches

_____ var. **canadensis**

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CAREX REZNICEKII, A NEW WIDESPREAD SPECIES OF *CAREX* SECTION *ACROCYSTIS* (CYPERACEAE) FROM EASTERN NORTH AMERICA

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ABSTRACT

Carex reznicekii is described as new from mesic to dry-mesic forests of Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Georgia, Kentucky, Maryland, Mississippi, Missouri, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Tennessee, and Virginia. Previously, *C. reznicekii* had mostly been misidentified as either *C. umbellata* or *C. nigromarginata*. It is distinguished from these species as well as other members of section *Acrocystis* by a combination of lack of basal spikes, short culms, narrow leaves, and only slightly red pistillate scales. A key to the 19 taxa of section *Acrocystis* that occur in eastern North America is provided.

RESUMEN

Se describe como nuevo **Carex reznicekii** de los bosques mésicos a xérico-mésicos de Alabama, Arkansas, Carolina del Norte, Carolina del Sur, Connecticut, Delaware, Distrito de Columbia, Georgia, Kentucky, Maryland, Mississippi, Missouri, New Jersey, New York, Pennsylvania, Rhode Island, Tennessee, y Virginia. Previamente, *C. reznicekii*, había estado en su mayor parte mal interpretada como *C. umbellata* o *C. nigromarginata*. Se distingue de estas especies así como de otros miembros de la sección *Acrocystis* por la combinación de carencia de espiga basal, cúlmenes cortos, hojas estrechas, y escamas femeninas sólo levemente rojas. Se proporciona una clave para los 19 taxa de la sección *Acrocystis* que ocurren en el este de Norteamérica.

INTRODUCTION

Carex section *Acrocystis* Dumort. contains approximately 35 species worldwide with 20 in North America (Crins & Rettig 2002), although the most recent comprehensive treatment is Kükenthal's (1909) now outdated revision. Species distributions lie mostly in Eurasia and North American with one taxon known from South America (Kükenthal 1909). It appears that *Carex* section *Acrocystis* as currently circumscribed is polyphyletic, but North American species and some Eurasian species form a clade (Roalson et al. 2001; Roalson & Friar 2004). Twenty-eight taxa, including the one described here, are currently known from North America, with 19 of these occurring in eastern North America (Crins & Rettig 2002). At least two additional undescribed species occur in eastern North America (Crins & Rettig 2002; Roalson & Friar 2004; Anton Reznicek, pers. comm.).

Eastern North American taxa of section *Acrocystis*, share the following characters: perigynia pubescent (except *C. tonsa* (Fernald) Bicknell var. *tonsa*), two veined, and abruptly narrowed to a distinct beak; stigmas three (except two and three in *C. floridana* Schwein.); non-basal pistillate spikes (when present) subtended by sub-sheathing to sheathless bracts, approximate, the distal ones short pedunculate to sessile; and habitats dry to mesic forests (tending to favor drier) or more open for a few taxa.

During survey work in the Hudson Highlands of southeastern New York, I found a

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population of the New York State endangered *C. nigromarginata*. While delineating and describing this population I encountered a population of a strikingly different plant, which at first appeared to be *C. umbellata* because all of its culms were very short and hidden in the bases of the plants. Upon closer inspection, I observed that these short-culmed plants lacked the basal spikes characteristic of *C. umbellata*. These short-culmed plants were uniform throughout its population and appeared immediately adjacent to and clearly did not resemble *C. nigromarginata*. In contrast to the *C. nigromarginata* population, these short-culmed plants had much narrower leaves, uniformly very short culms, and pale pistillate scales. Wider sampling showed that the short-culmed plants formed discreet uniform populations, although sometimes occurring mixed with, but seemingly not intergrading with, *C. nigromarginata*. A cursory examination of herbarium material also suggested that the distributions of the two entities were different. This new species of *Carex* is described here as *Carex reznicekii*.

MATERIALS AND METHODS

Specimens of *C. reznicekii* were sought by examining all specimens labeled as *C. nigromarginata* Schwein. and *C. umbellata* Schkuhr ex Willd. (two superficially similar species) and in some cases other members of section *Acrocystis* from BH, BRIT, GH, MO, NCU, NY, NYS, PH, and US. In addition, putative *C. reznicekii* specimens were sent to me from collections at DOV, MICH, and VPI as well as by Philip E. Hyatt. Additional specimens were gathered from field work. Type material was examined of all species similar to or confusable with *C. reznicekii*, including their synonyms.

Thirty-one populations were visited in the field, covering a large part of the species' range. Site visits were conducted to assess habitat affinities, morphological variability, and habitat differences with other members of *Carex* section *Acrocystis*. Soil samples were collected at six distant sites throughout a large part of the range of the species (Fig. 1). Equal amounts of soil from four places at each of the six sites (adjacent to individual *C. reznicekii* plants) that were at least 10 meters apart were mixed together. These were sent to Cornell Nutrient Analysis Laboratories at Cornell University, Ithaca, NY for analysis. Soils were analyzed for particle size distribution, pH, and the minerals Al, Ca, Fe, K, Mg, Mn, P, and Zn.

To clarify the differences between *C. nigromarginata*, the most similar species to *C. reznicekii*, and *C. reznicekii*, specimens were compared using eight continuous characters (see Table 1). Specimens were selected so as to have ten specimens per species from each of three geographic regions: 1) northeast (Virginia/Kentucky north), 2) southeast (North Carolina/Tennessee south), and 3) Arkansas/Missouri. Only six adequate specimens were available for *C. reznicekii* from the latter region. Within each geographic region (excluding Arkansas/Missouri), only two specimens per state and one per county were selected to help cover the range of the species. For each species, specimens were selected randomly given the parameters mentioned above and excluding specimens where all eight characters could not be measured. Analysis of variance (two-way ANOVA) and Pearson Correlation Coefficients were calculated using SPSS Version 13. Additionally, ranges, means, and standard deviations were calculated for both species for each region.

Nonmetric multidimensional scaling (NMDS) ordination was chosen to compare the relationship of *C. nigromarginata* and *C. reznicekii*. In comparison to other ordination methods such as canonical correspondence analysis (CCA) or principle components analysis (PCA), NMDS does not assume an underlying distribution for measured vari-

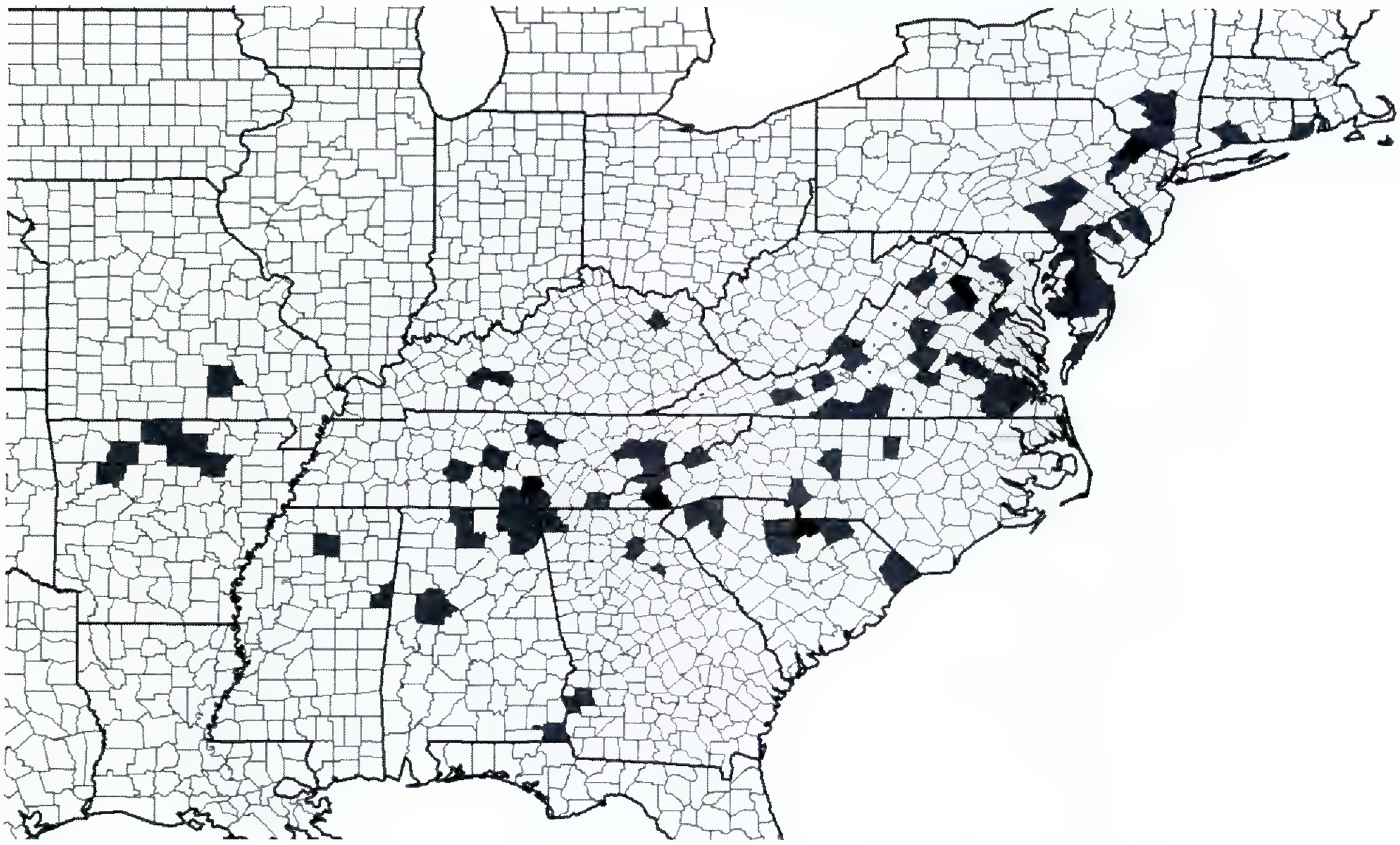


FIG. 1. Geographic distribution of *C. reznicekii*. Soil samples collected in blackened counties.

ables. A NMDS ordination was created using the slow thorough mode on PC-ORD (McCune & Grace 2002). Specimens measured for use in the ordination are delineated by a single asterisk in the isotypes listed for *C. reznicekii*, in the representative specimens of *C. reznicekii*, and in the specimens cited in Appendix A.

A scatter plot graph using a larger sample size was created for the two most explanatory characters. As additional evidence that *C. reznicekii* and *C. nigromarginata* are discreet entities, distribution curves were created and compared for the two most explanatory characters for *C. nigromarginata* and *C. reznicekii*, as well as *C. nigromarginata* and *C. reznicekii* combined, and *C. nigromarginata* specimens from outside the geographic range of *C. reznicekii*. For the latter distribution curves all specimens of *C. nigromarginata* that occur outside of the geographic range of *C. reznicekii* from BH, BRIT, MICH, and MO, excluding duplicates, were measured. Specimens measured for the scatter plot graph and distribution curves are delineated by either a single or double asterisk in the isotypes listed for *C. reznicekii*, in the representative specimen of *C. reznicekii*, and in the specimens cited in Appendix A.

A description of *C. reznicekii* and a key to all members of *Carex* section *Acrocystis* were created from original measurements except, for the key, measurements for *C. communis* Bailey varieties and *C. inops* Bailey ssp. *heliophila* (Mackenzie) Crins are adapted from Crins and Rettig (2002). Character states that were on an extreme edge or disjunct from most other measurement are placed in parentheses. The following notes clarify three characters listed in the description and the key.

1. Culm length is measured from the base of the culm to the top of the inflorescence as interpreted or implied by many other authors (LeBlond et al. 1994; Reznicek & Camelbeke 1996; Naczi et al. 2001; and others).

2. Terminal staminate spikes exceeding or exceeded by the rest of the inflorescence is

TABLE 1. Characters measured for ordination, ANOVA, and Pearson Correlations giving the codes used throughout the paper and any specifications for choosing which part to measure.

Character	Code	Specifications
Tallest culm height (cm)	TaCuHe	Tallest per specimen
Widest leaf width (mm)	WiLeWi	Widest per specimen
Anther length (mm)	AnLe	Mean of two per specimen
Largest length that a staminate spike exceeds the distal most pistillate spike (mm)	StSpExPiSp	Greatest length per specimen
Perigynia length (mm)	PeLe	Mean of two per specimen
Perigynia width (mm)	PeWi	Mean of two per specimen
Taller staminate spike length (mm)	StSpLe	Mean of the length of two taller staminate spikes per specimen
Staminate spike width (mm)	StSpWi	Mean of the width of the two staminate spikes measured for spike length

measured by subtracting the difference of the length from the base of the bract subtending the proximal-most non-basal spike to the apex of the terminal staminate spike, and the length from the base of this same bract to the apex of the distal most lateral spike.

3. Perigynium body refers to the perigynium excluding the beak and stipe or stipe-like base. The beak and stipe begin at the deepest point in the concavity formed at the summit and base of the perigynium. Perigynium body shapes vary considerably and although their shape aids in distinguishing taxa (and is used in the key), they should be used cautiously.

RESULTS

Carex reznicekii Werier, sp. nov. (**Fig. 2**). TYPE: U.S.A. VIRGINIA. Caroline Co.: near North Anna River, Route 207 (Jericho Road) W from Carmel Church to Oxford Road (Route 689), 3.6 mi S and SE on Oxford Road (Route 689) to small dirt road on S side of road; SW along dirt road towards North Anna River, UTM coordinates in NAD-83 Zone 18 4196701N 280996E, 10 Apr 2004, *Werier 1951* (HOLOTYPE: BH; ISOTYPES: GH*, MICH, MO, NCU, NY, US).

Carici nigromarginatae similis, sed characteribus sequentibus differt: laminis foliorum latissimis 1.2–2.2(–2.5) mm latis; culmis singulae plantae saepe in longitudine similibus longissimis 1.9–9.9(–13.7) cm longis, spicis staminalibus 3.3–8.3(–9.2) mm longis et 0.4–1.6(–1.8) mm latis; et colore rubenti squamarum pistillatarum ad regiones marginales restricto.

Densely caespitose, herbaceous, evergreen perennial. **Rhizomes** horizontal, ascending, or erect, 0.1–3.8 mm long between shoots or branches of the rhizomes, 0.6–1.2 mm wide with leaf sheaths absent, enclosed by leaf sheaths and/or cataphylls, which disintegrate into long fibers. **Vegetative shoots** erect to ascending, arising from buds at the tip or side of the rhizomes, or directly from the apical meristem of rhizomes or previous year's vegetative shoots; bases consisting of cataphylls or leaf sheathes which disintegrate into long fibers; **pseudoculms** (represented by leaf sheaths) 1.2–7.6 cm long. **Reproductive shoots** erect, mostly produced directly from the apical meristem of vegetative shoots or rhizomes, or less frequently produced from buds at tip or side of rhizomes, bases mostly surrounded only by leaf sheaths which disintegrate into long fibers, or less frequently surrounded by cataphylls; **culms** 1.3–9.9(–13.7) cm long, the tallest 1.9–9.9(–13.7) cm long, 0.3–0.5 mm wide just below the inflorescence, trigonous, with 1 elevated vein on each angle and 2–5 elevated veins on each side, smooth to minutely antrorsely scabrous on angles and veins,



FIG. 2. *Carex reznicekii*. **Bottom right,** plant (scale = 5 cm). **Bottom left,** Pistillate scales, perigynia, and achenes (scale = 1 mm). **Middle** (l to r), culm, inflorescence, and sheath (scale = 1 cm). **Top left,** staminate scale and anther (scale = 1 mm).

more prominently scabrous on angles and distally. **Cataphylls** at base of reproductive shoots 0–2, 1.6–10.8 mm long. **Leaves of reproductive shoots** 3–9. **Leaf blades** to 52.0 cm long, 0.7–2.2(–2.5) mm wide, the widest 1.2–2.2(–2.5) mm wide, flat to V-shaped, to occasionally M-shaped; adaxial surface dark green and smooth, papillose, or antrorsely scabrous, more textured distally; abaxial surface smooth to occasionally scabrous, more textured on mid-vein and distally; margins smooth to antrorsely scabrous, more scabrous distally; **leaf sheaths** 0.7–5.1 cm long, lower portion especially on outer sheaths have some red coloration; abaxial face with green to white or proximally red veins and whitish and translucent to proximally reddish and more opaque intervein regions; adaxial face with whitish or proximally red veins and whitish, thin, and translucent intervein regions, thinner and more translucent than abaxial intervein regions; vein edges with ascending, spreading, or reflexed minute, stiff, broad-based deltoid hairs; sheaths disintegrate into long fibers consisting of veins, which retain pubescence; adaxial sheath face apex concave to a depth of 0.3–0.8(–1.0) mm and sometimes slightly thickened; **ligules** typically wider than long, 0.3–1.0(–1.5) mm long (including the free portion), 0.6–1.4 mm wide, free portion of ligule 0.1–0.2 mm long, ciliate with abundant minute, stiff, broad-based deltoid hairs. **Infructescences** 5.2–12.9(–16.7) mm long, consisting of 3–5 approximate spikes at the summit of the culm; **proximal-most internode** 0.8–3.7(–5.2) mm long; **bracts** sheathless; **proximal-most bract** with blade 3.6–23.0(–38.5) mm long, 0.6–1.8 mm wide, 3.9(–4.3) mm shorter than to 10.9(–23.5) mm taller than infructescences; distal bracts reduced. **Spikes** arising singly from nodes; **terminal spike** staminate, 3.3–8.3(–9.2) mm long, 0.4–1.6(–1.8) mm wide, on peduncle (0.2–)0.3–0.7 mm long, exceeding distal-most lateral spike by 3.7 mm to exceeded by distal-most lateral spike by 1.1(–1.6) mm; **lateral spikes** 2–4, pistillate, short-pedunculate, with a cladoprophyll towards base of peduncle; **proximal-most spikes** 3.4–7.2 mm long, (1.8–)2.2–4.4 mm wide, (3–)5–10(–12) flowered, on peduncles (0.3–)0.4–0.9(–1.4) mm long, with cladoprophyll (0.7–)1.7–2.8(–3.0) mm long. **Staminate scales** (2.5–)2.7–4.0 mm long, 0.7–1.8 mm wide, ovate to elliptic, apex acute to obtuse, with a green or yellowish longitudinal mid-stripe which includes the mid-vein, margins translucent, thin, whitish to occasionally yellowish-brown, often red sub-marginally forming a longitudinal stripe, more so toward apex of scales and on distal scales, mid-vein present, extending further toward the apex of the scale in more distal scales; distal scales with mid-vein raised, slightly antrorsely scabrous, and ending close to apex of scale or sometimes with mid-vein projecting as a short awn attached just proximal to the scale apex and projecting up to just beyond the apex of the scale; **Pistillate scales** 2.6–4.3 mm long, 1.0–1.9 mm wide, 0.9(–1.1) mm shorter than to 0.5 mm longer than associated perigynium, ovate to lanceolate to elliptic, apex acute to obtuse, with a green (to brownish) longitudinal mid-stripe which includes the mid-vein; margins translucent, thin, whitish to occasionally yellow-brown, often some reddish color sub-marginally forming a sub-marginal longitudinal stripe, more so distally on the scale; sub-marginal longitudinal red stripe (if present) does not extend laterally to immediately adjacent to mid-stripe except sometimes at apex of scale; mid-vein antrorsely scabrous and ending just before apex of scale or mid-vein, projecting as a short awn attached just proximal to the scale apex and projecting up to just beyond the apex of the scale; bases of scales often with a narrow red horizontal stripe just above attachment to spike axis. **Anthers** 3, (1.2–)1.3–1.9(–2.3) mm long. **Stigmas** 3, withering with age. **Perigynia** (2.5–)2.7–3.9 mm long, (0.8–)0.9–1.3(–1.5) mm wide, light green, occasionally sparsely red-punctate, obtusely trigonous to plano-convex in cross-section, with two prominent nerves that extend the length of the perigynia and occasion-

ally up to 8 less prominent nerves at base, papillose with papillae short-cylindric up to 0.01 mm long, as well as pubescent with small (less than 0.1 mm), predominately antrorsely directed, stiff, deltoid hairs, which are denser on the prominent nerves that extend into the beak teeth; **body** 1.4–1.9(–2.0) mm long, ellipsoid, gradually tapering to beak and stipe; **stipe** 0.5–1.0(–1.1) mm long; **beak** (0.4–)0.6–1.0 mm long, bidentate; **beak teeth** 0.1–0.3 mm long. **Achenes** (1.4–)1.5–1.8(–1.9) mm long, 0.9–1.2(–1.3) mm wide, ovoid, acutely to obtusely trigonous to plano-convex in cross-section, minutely papillose, yellow-green to green when immature, light to chestnut brown when mature.

Etymology.—I selected *reznicekii* as the epithet to honor Dr. Anton Reznicek, University of Michigan, who has inspired me and many others interested in carices. He has catalyzed a revival in the study of *Carex* which has revealed a tremendous amount of new information. In addition, he has contributed directly to a greater understanding of these plants through numerous articles and classes.

A total of 242 specimens (143 records) of *C. reznicekii* were examined. Of these, 125 specimens (88 records) were collections made prior to recognition of *C. reznicekii*. Seventy-one of these 125 specimens had at one point been labeled *C. nigromarginata*, 78 *C. umbellata* (including *C. abdita* Bicknell and *C. umbellata* var. *brevirostris* Boott), 6 *C. floridana* [including *C. nigromarginata* var. *floridana* (Schwein.) Kükenthal], and 9 *C. albicans* Willd. ex Spreng. var. *emmonsii* (Dewey ex Torr.) Rettig [including *C. emmonsii* Dewey ex Torr. and *C. nigromarginata* var. *minor* (Boott) Gleason]. The sum totals to more than 125 because some specimens had been annotated numerous times.

Type material examined comprised the following: *C. umbellata*, scan of holotype from B; *C. umbellata* var. *vicina* Dewey, holotype at GH, isotype at PH; *C. umbellata* var. *brevirostris*, isotype at US (holotype not examined but specimen is from Saskatchewan); *C. abdita*, holotype at NY; *C. microrhyncha* Mackenzie, holotype at NY; *C. umbellata* var. *tonsa* Fernald, lectotype and 2 isolectotypes at GH; *C. rugosperma* Mackenzie, holotype at NY; *C. nigromarginata*, holotype at PH; and *C. floridana*, holotype at PH. None of the types examined proved to be *C. reznicekii*.

A detailed comparison of *C. reznicekii* to *C. umbellata* and *C. nigromarginata* is made below. In the past, *C. reznicekii* has been mistaken most often for these two species. *Carex nigromarginata* is most similar. The key compares all members of section *Acrocystis* from eastern North America.

Carex umbellata superficially resembles *C. reznicekii*, but is actually quite distinct. The two species can easily be fully separated by noting the presence (*C. umbellata*) or absence (*C. reznicekii*) of basal spikes. Mackenzie (1913), clearly stated this when he explained how to distinguish *C. nigromarginata* and *C. floridana* from *C. umbellata* and its allies. He stated, "these [*C. nigromarginata* and *C. floridana*] are to be distinguished by the fact that while the spikes are on very short culms and may appear basal they are not on basal peduncles." Fernald (1902) apparently did not understand the concept of basal spikes when he stated that "the best means of distinction between *C. umbellata* [misapplied to *C. tonsa* var. *rugosperma* (Mackenzie) Crins] and *C. nigro-marginata* [sic.] is offered by the thickness of the perigynia." In his 8th edition of Gray's Manual, Fernald (1950) placed *C. nigromarginata* with the basal spike members of section Acrocystis (as Montanae Fries) and then used perigynium characters and geographic region to distinguish *C. nigromarginata* from *C. umbellata* and its allies. This means of distinction appears to have been followed by at least Cusick (1992) and Tucker (1995), and may have in part resulted in *C. reznicekii* often being misidentified as *C. umbellata*.

Other characters that separate *C. umbellata* from *C. reznicekii* include the following: *C. umbellata* has staminate spikes with 0–2 approximate pistillate spikes vs. 2–4 for *C. reznicekii*; some pistillate spikes on elongate peduncles vs. none on elongate peduncles for *C. reznicekii*; staminate spikes extending up to 9.0 mm beyond the approximate (if present) pistillate spikes vs. staminate spikes at most extending 3.7 mm beyond the pistillate spikes for *C. reznicekii*; and perigynia (2.2–)2.3–3.2(–3.3) mm long vs. perigynia (2.5–)2.7–3.9 mm long for *C. reznicekii*. In addition, leaf blades of *C. umbellata* are generally lighter green and slightly wider than *C. reznicekii*.

A full understanding of basal spikes seems particularly important to understanding the difference between these two species, and may enrich the understanding of section *Acrocystis* as a whole. Basal spikes are individual pistillate spikes which arise almost directly from the base of the plant [subradical of Mackenzie (1913)]. These pistillate spikes have elongated peduncles, and as with all pistillate spikes in section *Acrocystis*, they are subtended by bracts. These bracts have sheaths and blades [contrary to Mackenzie (1935) and Roalson and Friar (2004) that state that section *Acrocystis* (*Montanae* of Mackenzie) has bracts which are sheathless or subsheathing]. These authors probably meant that bracts of **non-basal spikes** are sheathless or subsheathing. In addition, the culms of *C. umbellata* (defined as from the bases of the culms to the apices of the inflorescences) are often much taller than the apices of the basal pistillate spikes. Roalson and Friar (2004) consider basal pistillate spikes to be better described as a continuous character with somewhat distinct states, as opposed to a discrete character. While in essence this could be true, it appears that this character functions in two completely distinct states with associated other characters (elongated peduncles and sheathing bracts). Even more interestingly, while neither *C. nigromarginata* nor *C. reznicekii* has basal spikes, both often have "grouped culms." These "grouped culms" have one culm which is taller and one to three which are shorter (much less pronounced in *C. reznicekii*), mimicking the tall and short aspect of *C. umbellata*, with its often tall culms and shorter basal pistillate spike peduncles. In addition, the shorter culms in a "group" of culms in *C. nigromarginata* and *C. reznicekii* have relatively shorter and less projecting terminal staminate spikes.

Carex reznicekii and *C. nigromarginata* share a few characters, including no basal spikes, no elongated rhizomes, at least some culms short and hidden in leaf bases, perigynia of similar length, stigmas 3, and inflorescences composed of 3–5 approximate spikes. Likely because of these similarities, *C. reznicekii* has often been misidentified as *C. nigromarginata*.

Several characters separate these two species. First, *C. reznicekii* has narrower leaves with the widest per plant 1.2–2.2(–2.5) mm wide vs. (1.9–)2.3–4.5 mm wide for *C. nigromarginata*. Second, the tallest culms per plant are shorter. For *C. reznicekii* the tallest culms are 1.9–9.9(–13.7) cm long vs. (4.5–)6.6–38.0(–51.0) cm long for *C. nigromarginata*. Third, individual plants of *C. reznicekii* have culms often about the same length compared to widely different lengths among individuals of *C. nigromarginata*. Fourth, *C. reznicekii* culms remain erect even at maturity while some culms droop at maturity for *C. nigromarginata*. Fifth, *C. reznicekii* has margins of pistillate scales without red or red only submarginally. The red coloration (if present) can form a submarginal longitudinal stripe, but does not extend laterally to the green (or brown) longitudinal mid-stripe of the scale except at the apex. *Carex nigromarginata* has pistillate scales either similar in color to *C. reznicekii* or more often with dark reddish to dark purplish/black coloration

that extends laterally from the submargin to the green (or brown) mid-stripe of the scale. In addition, the red to purple color often extends all the way to the base of the scale in *C. nigromarginata*, while in *C. reznicekii* the reddish color (if present) does not extend to the base of the scale. Sixth, the apex of the staminate spike in *C. reznicekii* exceeds the apex of the distal-most lateral spike by at most 0.0–3.7 mm. In *C. nigromarginata*, the apex of the staminate spike which exceeds the apex of the distal-most lateral spike the most, exceeds it by (0.0–)0.5–5.1(–7.3) mm. While this character exhibits considerable overlap in these two species, it can sometimes be useful for distinguishing difficult specimens. Seventh, *C. reznicekii* has staminate spikes on average slightly shorter and narrower, measuring 3.3–8.3(–9.2) × 0.4–1.6(–1.8) mm vs. 4.2–10.9(–12.0) × 0.5–2.4(–2.8) mm for *C. nigromarginata*. Again this character shows significant overlap, but it occasionally provides useful help in distinguishing between these two species.

Carex reznicekii and *C. nigromarginata* were compared for eight continuous characters (see Table 1). Ranges, means, and standard deviations for all eight continuous characters measured for the NMDS ordination are presented in Table 2. Comparing *C. nigromarginata* and *C. reznicekii*, PC-ORD recommended a two-dimensional solution for the NMDS ordination. This resulted in a final ordination (see Fig. 3) with low instability (<0.001) indicating convergence of the iterations, and low stress (6.61) indicating that the data was far from random and there was "no real risk of drawing false inferences" (McCune & Grace 2002). Axis 1 of the ordination represents decreasing TaCuHe (-0.961) and WiLeWi (-0.747) with the numbers in parentheses representing the Pearson Correlation Coefficients with Axis 1 (Fig. 3). Axis 1 explained 81% of the variability in the dataset. Axis 2 of the ordination represents increasing TaCuHe (0.772), WiLeWi (0.707), StSpExPiSp (0.883), StSpHe (0.899), and StSpWi (0.702) with the numbers in parentheses representing the Pearson Correlation Coefficients with Axis 2 (Fig. 3). Axis 2 explained an additional 17% of the variability for a total of 98% explained variability. Overall, the ordination summarizes a very structured dataset with several highly correlated variables and in addition shows that while the two species are distinct, some overlap of individual specimens exists. Pearson-correlations illustrated that all of the characters measured except width and length of the perigynia were strongly correlated with one another ($p < 0.01$), indicating a high level of redundancy of the characters used. The ordination is presented mainly as a visual tool to show how *C. reznicekii* and *C. nigromarginata* compare with numerous characters.

All of the characters measured except width and length of the perigynia differed significantly between *C. reznicekii* and *C. nigromarginata* (Table 3). The scatter plot graph, using a larger sample size for the two strongest characters separating the two species (tallest culm height and widest leaf width), shows almost all individuals can be determined using these two characters alone (Fig. 4). Ranges, means, and standard deviations for this larger sample size are presented in Table 4. Mainly depauperate or aberrant individuals were not separable with these two characters. These specimens were determined by the additional characters as discussed previously with scale color being the most useful.

Regional differences in the characters were significant only for width and length of perigynia (Table 2). Perigynia of *C. reznicekii* varied by geographical region with slightly narrower and shorter perigynia on plants from the northern region compared to the southern and Missouri/Arkansas regions. These statistically significant differences represent only minor variations and have questionable biological significance.

For the distribution curves for widest leaf width and tallest culm height a total of

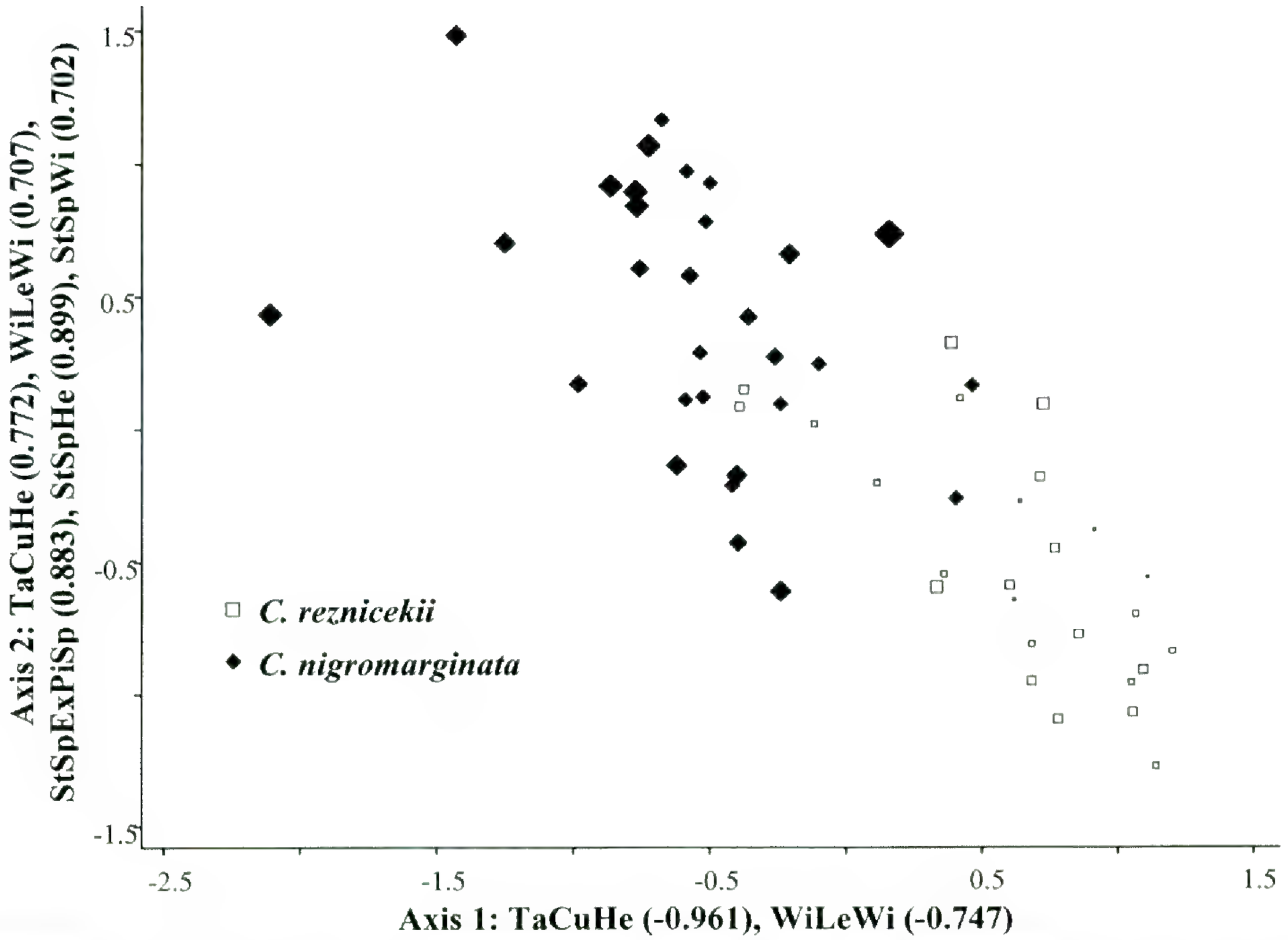


Fig. 3. Non-metric multidimensional scaling ordination showing spatial relationship of *C. reznicekii* and *C. nigromarginata* based on five explanatory characters. Symbols grade larger based on wider widest leaf blade widths. Main characters correlated to each axis are listed with their Pearson Coefficients in parentheses.

Table 2. Ranges, means, and standard deviations for characters measured for the NMDS ordination (Fig 3). Character codes are defined in Table 1. Regions listed below are as follows: NE = Virginia/Kentucky north; SE = North Carolina/Tennessee south; and AR/MO = Arkansas/Missouri.

	***Carex reznicekii* regions**				***Carex nigromarginata* regions**			
Characters	NE	SE	AR/MO	All regions	NE	SE	AR/MO	All regions
TaCuLe	2.2–12.2	2.5–13.7	3.7–13.7	2.2–13.7	9.0–27.7	6.6–18.7	7.2–38.0	6.6–38.0
	5.4±3.1	5.4±3.3	7.3±3.5	5.8±3.3	15.2±5.2	13.3±3.8	17.5±8.8	15.3±6.3
WiLeWi	1.3–2.2	1.3–2.0	1.7–2.2	1.3–2.2	2.4–4.0	2.4–3.5	2.5–3.5	2.4–4.0
	1.6±0.3	1.7±0.3	2.0±0.2	1.7±0.3	2.9±0.5	2.7±0.4	3.0±0.3	2.9±0.4
AnLe	1.30–1.80	1.30–1.95	1.50–1.75	1.30–1.95	1.50–2.20	1.45–2.25	1.60–2.50	1.45–2.50
	1.50±0.15	1.52±0.17	1.60±0.10	1.53±0.15	1.82±0.23	1.84±0.25	1.98±0.30	1.88±0.26
StSpExPiSp	0.2–2.5	0.2–2.2	1.1–3.7	0.2–3.7	0.7–7.3	1.1–6.0	0.5–5.5	0.5–7.3
	1.4±0.7	1.2±0.5	2.5±1.2	1.6±0.9	3.4±2.0	2.7±1.6	3.0±1.7	3.0±1.7
PeLe	2.75–3.45	2.80–3.70	3.35–3.55	275–3.70	2.70–3.30	2.90–3.60	3.00–3.75	2.70–3.75
	3.16±0.21	3.23±0.27	3.40±0.10	3.24±0.23	3.14±0.18	3.27±0.25	3.37±0.25	3.26±0.24
PeWi	0.95 1.10	1.05 1.20	1.05–1.20	0.95–1.20	0.95–1.35	0.90 1.35	1.05–1.25	0.90–1.35
	1.02±0.06	1.13±0.05	1.13±0.07	1.09±0.08	1.11±0.11	1.14±0.12	1.12±0.07	1.12±0.10
StSpHe	4.60–7.55	4.60–7.85	5.80–9.00	4.60 9.00	5.85–12.10	6.15 11.15	5.35–10.70	5.35–12.10
	6.31±0.89	6.05±1.05	7.33±1.21	6.45±1.11	8.41±2.13	7.79±1.58	8.02±1.74	8.07±1.79
StSpWi	0.90 1.55	0.70 1.65	1.05–1.65	0.70–1.65	1.05–2.25	1.00–2.00	1.35 1.75	1.00 2.25
	1.27±0.20	1.20±0.28	1.31±0.22	1.25±0.23	1.62±0.36	1.50±0.31	1.52±0.15	1.54±0.28

TABLE 3. Summary of F statistics and probability values from one-way ANOVA between *C. reznicekii* and *C. nigromarginata* for characters measured for ordination.

Characters	$F_{1,50}$	p
TaCuLe	43.8	<0.001
WiLeWi	136.2	<0.001
AnLe	32.6	<0.001
StSpExPiSp	12.3	0.001
PeLe	0.0	0.914
PeWi	1.6	0.208
StSpHe	13.3	0.001
StSpWi	15.7	<0.000

TABLE 4. Ranges, means, and standard deviations for characters measured for the scatter plot graph and character distribution curves (Fig. 4, 5, and 6).

	C. reznicekii **150 specimens**	***C. nigromarginata*** **(includes specimens from inside and outside the range of *C. reznicekii*) 152 specimens**	***C. nigromarginata*** **outside of range of *C. reznicekii* 81 specimens**
TaCuLe	1.9–13.7	4.5–51.0	4.5–51.0
	5.3±2.6	16.5±7.5	19.1±8.0
WiLeWi	1.2–2.5	1.9–4.5	2.1–4.4
	1.7±0.3	2.9±0.5	3.0±0.5

TABLE 5. Ranges, means, and standard deviations of particle sizes, pH, and mineral contents of six soil samples.

	Measurements		**Measurements**
Sand	31–88%	**Mg**	33.67–221.09 ppm
	57±20		136.10±71.84
Silt	9–54%	**Ca**	220.28–5509.98 ppm
	29±15		1732.66±1931.26
Clay	2–27%	**Fe**	0.64–45.38 ppm
	14±10		16.00±20.97
pH	4.35–6.51	**Al**	15.51–317.91 ppm
	5.49±1.02		111.96±117.45
P	0.89–6.40 ppm	**Mn**	20.43–93.99 ppm
	2.35±2.06		69.17±27.38
K	24.76–268.13 ppm	**Zn**	0.87–9.21 ppm
	125.79±82.20		3.54±3.02

150 specimens of *C. reznicekii* and 152 specimens of *C. nigromarginata* were measured. Eighty-one of the *C. nigromarginata* specimens were from outside of the geographic range of *C. reznicekii*. The distribution curves for widest leaf width and tallest culm height for *C. nigromarginata* and *C. reznicekii* combined shows a bimodal distribution of these characters (Fig. 5 and 6). The distribution curves for *C. nigromarginata* and *C. reznicekii* as separate taxa are overlapping normal or skewed normal curves (Fig. 5 and 6). The distribution curves for specimens of *C. nigromarginata* from outside the range of *C. reznicekii* closely mimic the distribution curve for *C. nigromarginata* throughout its range and also clearly contrasts with the distribution curves of *C. reznicekii* (Fig. 5 and 6). These distri-

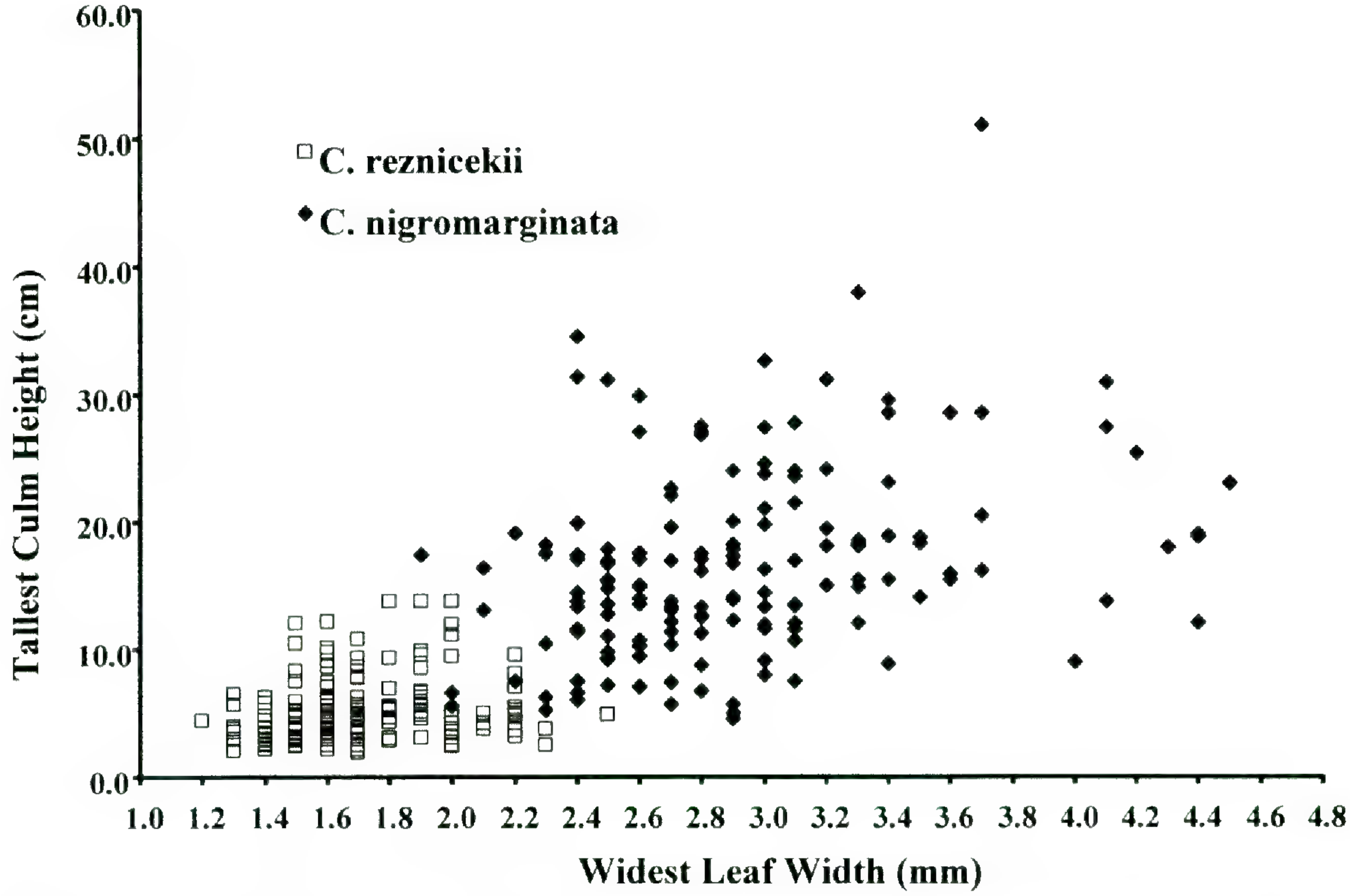


FIG. 4. Scatter plot of all specimens examined for widest leaf width by tallest culm height for *C. nigromarginata* and *C. reznicekii*.

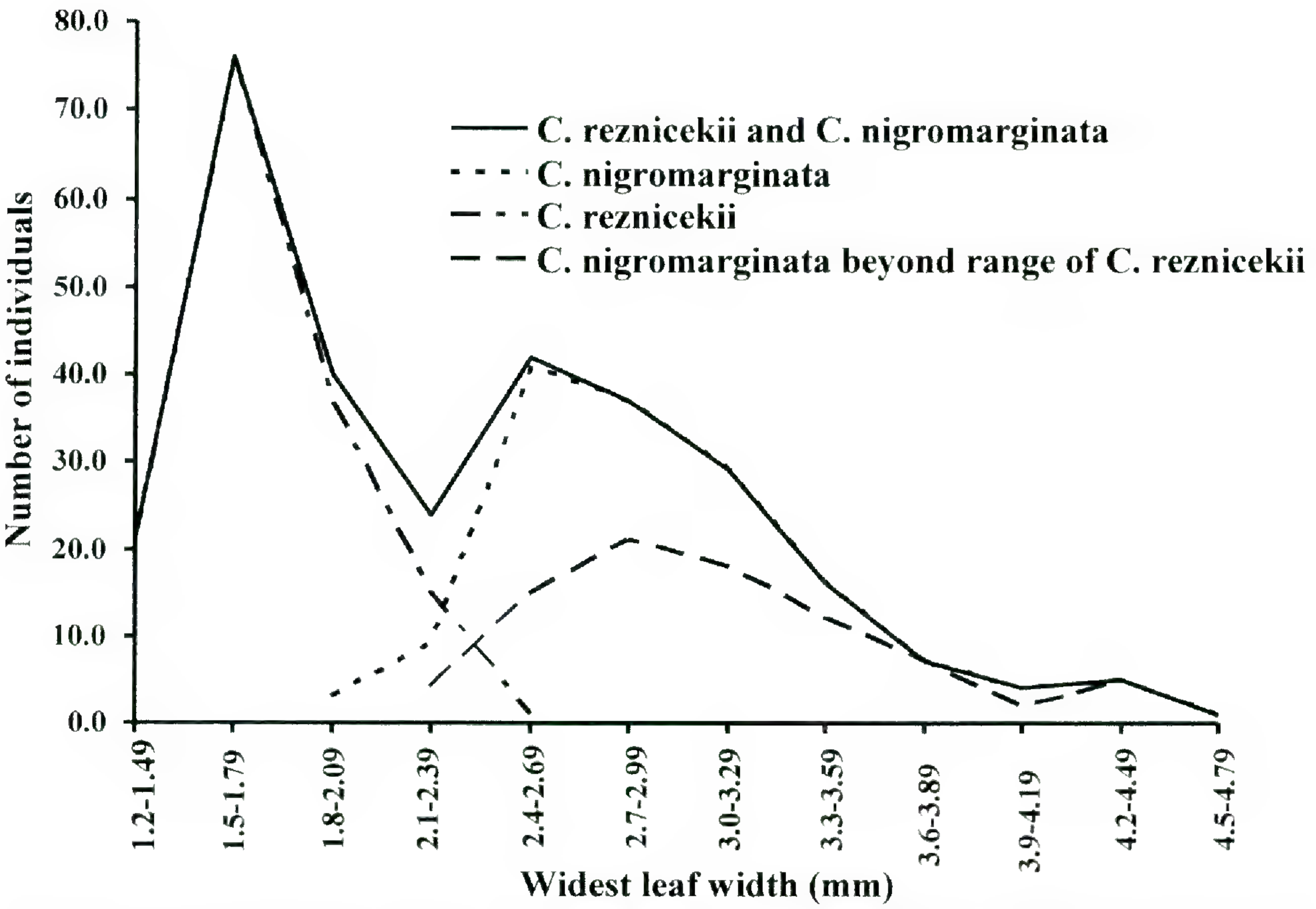


FIG. 5. Distribution curves for widest leaf width for *C. reznicekii*, *C. nigromarginata*, *C. reznicekii* and *C. nigromarginata* combined, and *C. nigromarginata* specimens outside the geographic range of *C. reznicekii*.

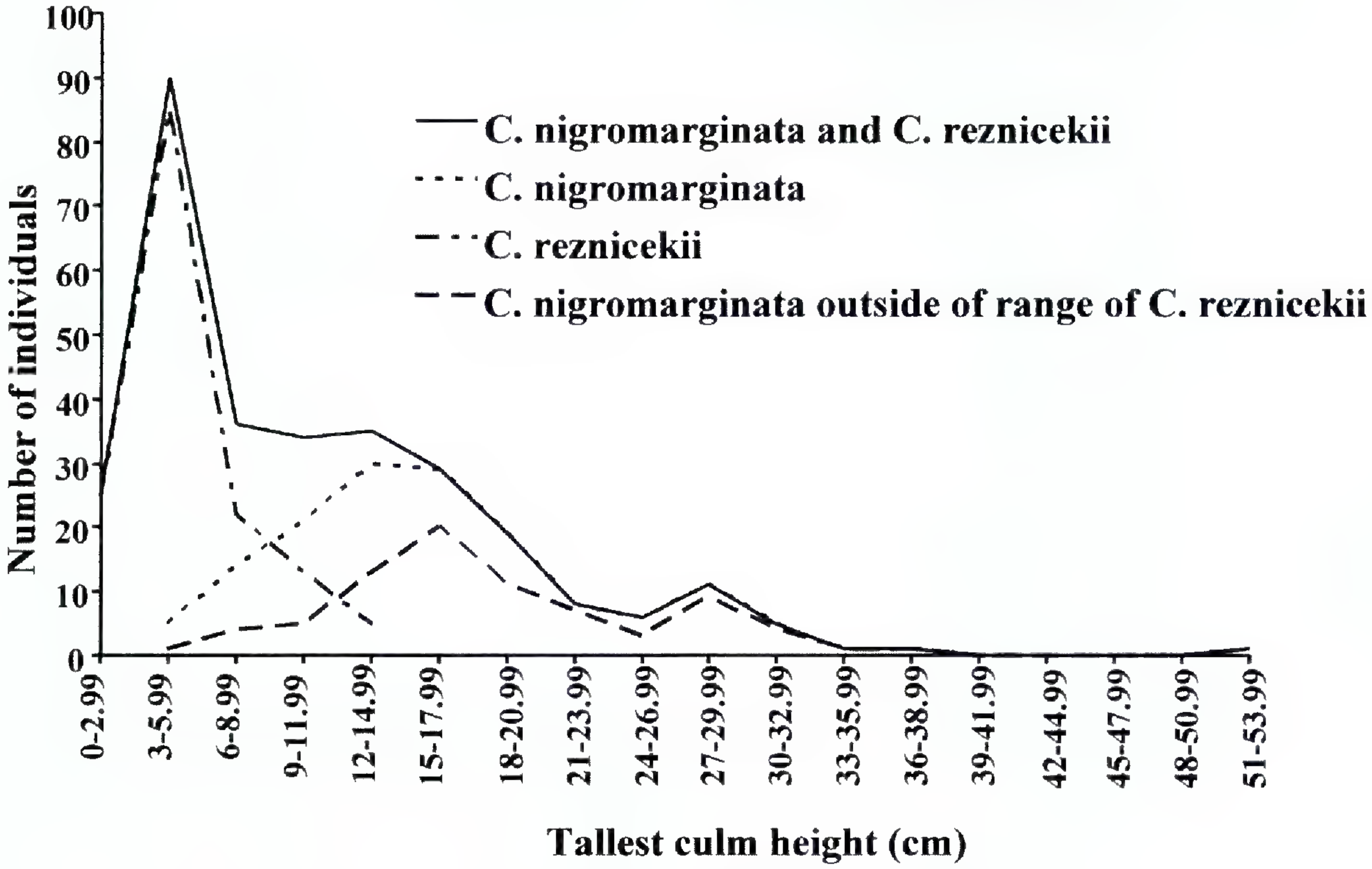


FIG. 6. Distribution curves for tallest culm height for *C. reznicekii*, *C. nigromarginata*, *C. reznicekii* and *C. nigromarginata* combined, and *C. nigromarginata* specimens outside the geographic range of *C. reznicekii*.

bution curves help to demonstrate that although there is some overlap in the two most explanatory characters that separate *C. nigromarginata* and *C. reznicekii*, the distinction between these two species is not a result of a sampling bias. The two species simply have slightly overlapping normal or skewed normal distribution curves.

Geography

Carex reznicekii occurs from New England (southern Rhode Island and southern Connecticut) south to southeastern New York, eastern Pennsylvania, South Carolina, and Georgia west to southern Missouri and northern Arkansas (Fig. 1). It is quite common in the southeastern US.

The range of *C. reznicekii* appears to be totally within the range of *C. nigromarginata* and *C. umbellata* (Crins & Rettig 2002). The distribution of *C. nigromarginata* extends beyond the range of *C. reznicekii* into southern Ontario, central and western Pennsylvania, southern Ohio, Indiana, Illinois, central Missouri, central and southern Arkansas, Oklahoma, Texas, Louisiana, southern Mississippi, southwestern Alabama, and the panhandle of Florida (specimens examined, Reznicek & Catling 1982; Cusick 1992; Crins & Rettig 2002). The distribution of *C. umbellata* extends well beyond the range of *C. reznicekii* into Greenland, eastern and western Canada, and from Nebraska south to Texas (Crins & Rettig 2002).

Ecology

Carex reznicekii occupies mesic to dry-mesic mostly deciduous or less commonly deciduous-pine and/or *Ilex opaca* Aiton forests. Overstory tree canopy cover often exceeds ca. 60% but does not create dense shade. The shrub layer is usually not very dense. The herb layer varies from quite diverse to not diverse, and quite dense to not dense. Occa-

sionally C. reznicekii grows in clearings in forests. Even at these sites, it is mostly found in the adjacent full-canopy forests. It also occurs along road edges immediately adjacent to forests as well as in the forest interior. Overall, it grows predominately in full-canopy forests, and unlike some other members of section *Acrocystis* (e.g., *C. nigromarginata* and *C. umbellata*), it usually does not do equally as well in more open environments.

Carex reznicekii often occurs on slopes above drainages from the bases of the slopes to mid-slopes and occasionally on the upper slopes or crests. It usually does not occur in the actual floodplain of the adjacent drainage unless the drainage is relatively small. Additionally, *C. reznicekii* usually does not occur on upper slopes, especially if ericaceous shrubs and *Quercus montana* Willd. are dominant.

Many members of *Carex* section *Acrocystis* in eastern North America often grow together. Perhaps this is because they grow in a "generalized" habitat (Cusick 1992). Other members of section *Acrocystis* observed growing syntopically with *C. reznicekii*, often within centimeters of it, include *C. albicans* var. *albicans*, *C. albicans* var. *emmonsii*, *C. nigromarginata*, *C. pensylvanica* Lamarck, *C. tonsa* var. *tonsa*, *C. tonsa* var. *rugosperma*, and *C. umbellata*. *Carex nigromarginata* occurred as the most frequent associate, being found with *C. reznicekii* at 19 out of the 31 sites visited. Despite *C. nigromarginata* frequently growing syntopically with *C. reznicekii*, some habitat differences between the two were observed. *Carex reznicekii* usually grew without or with low densities of *C. nigromarginata* in more calcareous or richer sites as well as lower on slopes. *Carex reznicekii* usually did not occur or occurred in lower densities with *C. nigromarginata* at more acidic sites, higher up on slopes, or in more open disturbed habitats.

Soils are deep or less frequently shallow over bedrock. Bedrock present at sites includes diabase, limestone, shale, and sandstone. Soil samples showed a wide variety of soil textures ranging from sandy to sandy loam to silty loam to sandy clay loam to clay loam. Table 5 summarizes the ranges, means, and standard deviations of values for particle size, pH, and mineral content of the six soil samples.

IDENTIFICATION KEY FOR MEMBERS OF *CAREX* SECTION *ACROCYSTIS* EAST OF THE ROCKY MOUNTAINS OF NORTH AMERICA

This key works best with ample specimens in mature fruit. Depauperate or especially robust specimens may not key correctly. Rhizomes help in identification, but collectors often fail to collect them. The key attempts, where possible, to get around relying on rhizome characters. Parts of the key dealing with *C. communis* varieties and *C. inops* ssp. *heliophila* are adapted from Crins and Rettig (2002).

1. Culms with some pistillate spikes elongate-pedunculate arising from near base of culms (sometimes difficult to assess because peduncles can be hidden by sheathes of bracts and leaves until they emerge adjacent to distal half of culms); pistillate spikes arising from distal half of culms mostly 0–3.
2. Pistillate scales from slightly shorter to longer than the perigynia; terminal staminate spikes with or without approximate pistillate spikes; bracts at base of proximal-most non-basal pistillate spikes (if present) mostly shorter than to sometimes slightly longer than inflorescences; bases of old leaves often very fibrous.
3. Perigyn a (2.2–)2.3–3.2(–3.3) mm long, beaks (0.4)0.5–1.0 mm long _____ **Carex umbellata**
3. Perigynia (3.0–)3.1–4.7 mm long, beaks 0.9–2.1 mm long.
4. Perigynia often mostly glabrous; young leaves short, thick, often smooth adaxially, and rigid _____ **Carex tonsa** var. **tonsa**
4. Perigynia usually pubescent; young leaves long, thin, scabrous adaxially, and not rigid _____ **Carex tonsa** var. **rugosperma**

2. Many pistillate scales shorter than mature perigynia; terminal staminate spikes almost always with at least one approximate pistillate spike; bracts at base of proximal-most non-basal pistillate spikes mostly longer than inflorescences; bases of old leaves not or only slightly fibrous.
   5. Perigynia (2.2–)2.6–3.1(–3.2) mm long, beaks 0.4–0.8 mm long, beak teeth up to 0.2 mm long; pistillate scales often shorter than the body of mature perigynia; staminate spike 3.5–5.9(–6.7) mm long; rhizomes slender; plants loosely caespitose _____ **Carex deflexa** Hornem. var. **deflexa**
   5. Perigynia 3.1–4.2 mm long, beaks 0.9–1.7 mm long, beak teeth 0.2–0.5 mm long; pistillate scales often longer than the body of mature perigynia; staminate spikes 4.2–11.6 mm long; rhizomes stout; plants densely caespitose _____ **Carex rossii** Boott
1. Culms with pistillate spikes short-pedunculate to sessile (proximal-most non-basal spikes occasionally elongate-pedunculate) and arising from distal half of culms [occasional culms will have one pistillate spike with an elongate peduncle arising from base of culms (these may represent hybrids)]; pistillate spikes arising from distal half of culms mostly 2–4.
   6. Longest staminate spike at least 12.3 mm long (use ample specimens); rhizomes elongated (except *C. albicans* var. *albicans*, *C. communis*, and *C. novae-angliae*: these key out in either lead of 6); perigynia bodies globose to ellipsoid, as long as or longer than wide.
      7. Widest perigynium equal to or less than 1.2 mm wide; widest leaf blades 1.1–2.7 mm wide; perigynia bodies ellipsoid, longer than wide.
         8. Widest leaf blades 1.1–1.8 mm wide; proximal internode of inflorescence 5.2–29(–40) mm long; staminate spike peduncles 1.2–8.0(–8.6) mm long; proximal-most pistillate spike peduncles 0.8–9.8 mm long; spike above the proximal most spike subtended by a bract which often has an elongate awn; pistillate scales not red, sometimes with some red-brown _____ **Carex novae-angliae** Schwein.
         8. Widest leaf blades 1.3–2.7 mm wide; proximal internode of inflorescence 1.0–13.2(–20.1) mm long; staminate spike peduncles 0.3–4.5(–8.8) mm long; proximal-most pistillate spike peduncles 0.3–2.2(–3.3) mm long; spike above the proximal-most spike subtended by a bract which usually has at most a short awn; pistillate scales sometimes partly red.
            9. Rhizomes elongate and spreading _____ **Carex albicans** var. **australis** (Bailey) Rettig
            9. Rhizomes short and ascending to erect _____ **Carex albicans** var. **albicans**
      7. Widest perigynium greater than 1.2 mm wide; widest leaf blades 1.5–6.1 mm wide; perigynia bodies often globose to broadly ellipsoid, about as long as wide to slightly longer than wide.
         10. Widest leaves (2.3–)3.0–6.1 mm wide; plants with large caespitose clumps; not colonial; rhizomes short and ascending to erect; bracts subtending the spike above the proximal-most with an elongate awn tip that arises from scarious margins that are truncate to convex at summit; staminate spikes 0.9–2.2(–2.5) mm wide.
            11. Perigynia beak teeth 0.1–0.2(–0.3) mm long; pistillate scales usually 1.6 mm wide or less; widespread _____ **Carex communis** var. **communis**
            11. Perigynia beak teeth usually more than 0.2 mm long; pistillate scales usually more than 1.6 mm wide; Georgia and South Carolina _____ **Carex communis** var. **amplisquama** (Hermann) Rettig
         10. Widest leaves less than 3.0(–3.5) mm wide; plants with small caespitose clumps; colonial; rhizomes spreading and long; bracts subtending the spike above the proximal-most with a short or no awn tip that arises from scarious margins that mostly taper into the distal part of the bract; staminate spikes (1.1–)1.5–3.2(–5.2) mm wide.
            12. Perigynia 1.1–1.6(–1.8) mm wide.
               13. Perigynia beaks 0.3–0.8(–0.9) mm long, beak/body ratio 0.13–0.50(–0.56) _____ **Carex pensylvanica**
               13. Perigynia beaks 0.9–1.6 mm long, beak/body ratio 0.50–0.92.
                  14. Widest leaf blades greater than (1.7–)2.0 mm wide; northeastern North America _____ **Carex lucorum** Willd. ex Link var. **lucorum**
                  14. Widest leaf blades less than 2.0 mm wide; southern Appalachian Mountains _____ **Carex lucorum** var. **austrolucorum** Rettig

12. Perigynia (1.6–)1.7–2.2 mm wide _____ **Carex inops** ssp. **heliophila**

6. Longest staminate spike less than 12.3 mm long (use ample specimens); rhizomes not elongated (except *C. floridana* and *C. albicans* var. *australis*: the latter keys out in either lead of 6); perigynia bodies ellipsoid, longer than wide (except *C. deflexa* and *C. communis*: the latter keys out in either lead of 6).

15. Pistillate scales shorter than body of mature perigynia they subtend.

16. Proximal internode of inflorescence 5.2–29(–40) mm long; staminate spikes (4.6–) 5.1–12.1 mm long _____ **Carex novae-angliae**

16. Proximal internode of inflorescence 1.3–8.5(–14.5) mm long; staminate spikes 3.5–8.3(–9.2) mm long.

17. Culms mostly surpassed by leaves; perigynia (2.2–)2.6–3.1(–3.2) mm long _____ **Carex deflexa var. deflexa**

17. Culms surpassing leaves; perigynia (3.0–)3.1–4.2 mm long _____ **Carex peckii** Howe

15. Pistillate scales longer than body of mature perigynia they subtend.

18. Widest leaf blades (2.3–)3.0–6.1 mm wide; proximal internode of the inflorescence (5.9–)7.5–36.0 mm long; bract subtending the spike above the proximal-most with an elongate awn tip that arises from scarious margins that are truncate to convex at summit; perigynia bodies globose to broadly ellipsoid, about as long to slightly longer than wide.

19. Perigynia beak teeth 0.1 0.2(–0.3) mm long; pistillate scales usually 1.6 mm wide or less; widespread _____ **Carex communis** var. **communis**

19. Perigynia beak teeth usually more than 0.2 mm long; pistillate scales usually more than 1.6 mm wide; Georgia and South Carolina _____ **Carex communis** var. **amplisquama**

18. Widest leaf blades 1.1–4.5 mm wide (if widest leaves are over 2.7 mm wide then proximal internode of the inflorescence 0.8–5.4 (8.0) mm long); bract subtending the spike above the proximal-most with or without an elongate awn tip that arises from scarious margins that mostly taper into the distal part of the bract (occasionally truncate to convex at summit); perigynia bodies ellipsoid, longer than wide.

20. Widest leaf blades 1.1–1.8 mm wide; proximal internode of inflorescence 5.2–29(–40) mm long; staminate spike peduncles 1.2–8.0(–8.6) mm long; proximal-most pistillate spike peduncles 0.8–9.8 mm long; spike above the proximal-most spike subtended by a bract which often has an elongate awn; pistillate scales without true red, sometimes with some red-brown _____ **Carex novae-angliae**

20. Widest leaf blades 1.2–4.5 mm wide; proximal internode of inflorescence 0.8–13.2(–20.1) mm long; staminate spike peduncles 0.1–4.5(–8.8) mm long; proximal-most pistillate spike peduncles 0.0–2.2(–3.3) mm long; spike above the proximal-most spike subtended by a bract which usually has at most a short awn; pistillate scales sometimes with some red.

21. Longest leaf blades up to 2.2(–2.7) times as long as the median culm length; perigynia 2.2–3.2(–3.3) mm long; proximal internode of inflorescence 1.0–13.2(–20.1) mm long; staminate spike peduncles 0.3–4.5(–8.8) mm long.

22. Rhizomes elongate and spreading _____ **Carex albicans** var. **australis**

22. Rhizomes short and ascending to erect.

23. Staminate spikes (5.5–)6.6–12.2(–14.5) mm long; middle and upper staminate scales mostly with midrib faint, not raised, not scabrous towards tip of scale, and mostly without a minute awn arising just below tip of scale _____ **Carex albicans** var. **albicans**

23. Staminate spikes 4.0–8.7(–9.3) mm long; middle and upper staminate scales mostly with midrib more prominent, raised, antrorsely scabrous towards tip of scale, and with a minute awn arising from just below tip of scale _____ **Carex albicans** var. **emmonsii**

21. Longest leaf blades at least (2.3–)2.5 times as long as the median culm length; perigynia (2.5–)2.7–4.0 mm long; proximal internode of inflorescence 0.8–5.4(–8.0) mm long; staminate spike peduncles 0.1–0.8(–1.6) mm long.

24. Rhizomes horizontally spreading to ascending and elongate; mostly at

least some stigmas 2; mostly at least some achenes with only 2 pale nerves; sheathes of old leaves at base of plant usually weakly fibrous ——— **Carex floridana**

24. Rhizomes ascending to erect and short; stigmas 3; achenes with 3 pale nerves; sheathes of old leaves at base of plant often strongly fibrous.
    25. Widest leaf blades 1.2–2.2(–2.5) mm wide; culms often about equal length, the longest 1.9–9.9(–13.7) cm long; any reddish color on pistillate scales below the distal tip not extending laterally from near the margin to the green or brown longitudinal mid-stripe on either side of mid-vein; the longest staminate spike up to 3.7 mm taller than the distal most lateral spike apex; staminate spikes 3.3–8.3(9.2) mm long × 0.4–1.6(–1.8) mm wide ——— **Carex reznicekii**
    25. Widest leaf blades (1.9–)2.3–4.5 mm wide; culms often of quite variable length, the longest (4.5–)6.6–38.0(–51.0) cm long; at least some pistillate scales often with reddish to purplish/black color below the distal tip extending laterally from near the margin to the green or brown longitudinal mid stripe on either side of mid-vein; the longest staminate spike (0.0–)0.5–5.1(–7.3) mm taller than the distal most lateral spike apex; staminate spikes 4.2–10.9(–12.0) mm long × 0.5 2.4(–2.8) mm wide ——— **Carex nigromarginata**

Representative specimens of *Carex reznicekii*: Specimens marked with a single asterisk were measured for the ordination (Fig. 3); the ones marked with a single or double asterisk were measured for the scatter plot graph and character distribution curves (Fig. 4, 5, and 6).

U.S.A. ALABAMA. Dekalb Co.: near top of Red Mountain, just NW of Fort Payne, 21 Apr 1943, *Harper 3918* (MO, US*), *Harper 3919* (BH**, GH, US). **Houston Co.:** vicinity of Columbia, Thomas Creek up to bluff along Ommussee Creek, 12 Mar 1998, *MacDonald 10970* (BRIT**). **Jackson Co.:** ca. 3 mi W of Carns, along E side of county Route 33, 22 Apr 2002, *Naczi 9034* (DOV**); just E of Route 35, 0.1 mi S of junction with Route 40, 21 Apr 2004, *Werier 2075* (BH*); county Route 33, 8.05 mi by road SE of junction with Route 79, 21 Apr 2004, *Werier 2081* (BH**, MICH, NCU). **Limestone Co.:** by I-65, ca. 5 mi N of US 31 turnoff to Athens, 26 Mar 1986, *Kral 73127* (BRIT**). **Morgan Co.:** by US 31, 1 mi S of Lacon, 12 Apr 1970, *Kral 38342* (BRIT**). **Tuscaloosa Co.:** by AL 69, 9 mi N of Moundville, 1 Apr 1984, *Kral 71138* (BRIT**). **ARKANSAS. Baxter Co.:** Cole Fork along Cripple Turkey Road, 26 Apr 1993, *Hyatt 5243* (MICH*). **Independence Co.:** 6.95 mi S of Sharp Co. Line (in Cave City) on US Hwy. 167, 9 Apr 1994, *Hyatt 5838* (MICH*), *Hyatt 5839* (MICH*). **Izard Co.:** ca. 0.5 mi SE of Baxter Co. on AR Hwy. 5, 18 Mar 1998, *Hyatt 7879* (MICH**). **Johnson Co.:** [Ozark National Forest], Horsehead Lake Recreation Area, western most picnic area, 12 Apr 1996, *Hyatt 6896* (MICH*). **Marion Co.:** Buffalo National River, 100-200 m NE of Buffalo River Bridge of state Hwy. 14, 10 Apr 1994, *Hyatt 5844* (MICH*). **Newton Co.:** S of Harrison, 0.8 mi N of Harp Creek, along Hwy. 7, 14 Apr 1984, *Castaner 7992* (DOV**). **Stone Co.:** Mountain View vicinity, about 10 mi SSE on AR Hwy. 5, 8.5 mi N of Cleburne Co. line, 18 Mar 1998, *Hyatt 7886* (MICH**). **CONNECTICUT. New Haven Co.:** City of New Haven, West Rock Ridge, a little N of "Judges Cave," 20 May 2005, *Werier 2533 & Haines* (BH**). **DELAWARE. Kent Co.:** above Choptank River floodplain at Sandtown landfill, N of Sandtown, 30 Apr 2003, *McAvoy 5742* (DOV*). **[New Castle Co.]:** Mount Cuba, 1 May 1898, *Bicknell 3255* (NY*); near Centreville, 28 Apr 1876, *Commons s.n.* (PH**). **Sussex Co.:** 3 mi E of Milford, along S side of Beaverdam Branch, ca. 0.2 mi W of its crossing by road 200, 21 Apr 2003, *Naczi 9521* (BRIT, DOV**). **[Sussex Co.]:** Laurel, 25 Apr 1882, *Smith 717* (US**). **[DISTRICT OF COLUMBIA]. [Washington Co.]:** Washington, 25 Apr 1897, *Steele s.n.* (GH**); District of Columbia and vicinity, 7 May 1899, *Williams s.n.* (NY**); Anacostia to Twining City, 7 Apr 1918, *Leonard 139a* (US**). **GEORGIA. Clarke Co.:** E of Athens, end of Rock and Shoals Road off Barnett Shoals Road, 24 Feb 1981, *Manhart 202* (BRIT**, MICH**, MO, NYS,). **Clay Co.:** 1 mi E of Fort Gaines, 27 Mar 1949, *Thorne & Muenscher 9312* (GH**). **Dade Co.:** Sitton's Gulch, Lookout Mountain, 2 mi SE, Trenton, 17 Mar 1939, *Hermann 10192* (GH*, NY**). **Hall Co.:** Chipowee Woods (Elachee Preserve), 19 Mar 2005, *Hyatt 11802* (BH**), 9 Apr 2005, *Hyatt 11807* (BH**). **Randolph Co.:** near Griers Cave, N of Cuthbert, 3 Apr 1948, *Thorne & Muenscher 7910* (BH**). **Walker Co.:** W side of GA Route 136, 1.6 mi by road W of GA Route 193, 0.4 mi W of Cooper Heights Community, 8 Apr 2000, *Hill 32220* (NY); just W of Route 136, 1.6 mi by road W of junction with Route 193, 20 Apr 2004, *Werier 2069* (BH*, MICH, NCU). **KENTUCKY. Butler Co.:** Roundabout Swamp, at end of Biggerstaff Road, off Hwy. 1153, 22 Apr 1993, *McKinney 5360* (MICH*). **Edmonson Co.:** Mammoth Cave National Park, Ugly Creek S from junction with Little Jordon Cemetery Road, 23 Apr 1991, *McKinney & Evans 4622* (BRIT**). **Rowan Co.:** Lick Fork, 4 Apr 1938, *Braun 1758* (US**). **MARYLAND. Caroline Co.:** Tuckahoe State Park, off Cherry Lane, approximately 1.2 mi S of junction with Mason Branch Road,

14 Apr 1997, *Frye 779* (MICH**), 2 May 2004, *Werier 2176* (BH*), *Werier 2178* (BH**, MICH, US); Tuckahoe State Park, entrance to Cherry Lane picnic area., 2 May 2004, *Werier 2181* (BH**, MICH, US). **Cecil Co.:** along Bohemia Creek, Middle Neck, 7 May 1932, *Long 37288* (PH**). **Dorchester Co.:** N side of Puckum Branch, W of Puckum Road, N of Eldorado, 15 May 2003, *McAvoy 5797, Elliott, & Elliott* (DOV*). **Kent Co.:** above the "Big Marsh," W of Betterton, 27 Apr 2003, *McAvoy 5739* (DOV**). **Montgomery Co.:** Plummer's Island in the Potomac River, near Cabin John, 10 May 1915, *Van Eseltine 325* (BH**). **Wicomico Co.:** S side of Bear Swamp Road, SW of Powellville, 18 Apr 1999, *McAvoy 4268* (DOV**). **MISSISSIPPI. Lafayette Co.:** NE of Oxford, 5.4 mi NE of junction of MS 7 and 30 on MS 30 then ca. 1 mi S on Hopewell Road, 12 Apr 1997, *Bryson 15732* (BRIT, DOV**). **Lowndes Co.:** 2.5 mi N of Steens, N side of Vaughn Robertson Road, 20 Apr. 1986, *Bryson 4217 & Curtis* (MICH, MO), 12 Apr 1987, *Bryson 5341* (MICH**). **MISSOURI. Shannon Co.:** above intermittent tributary of E branch of Dennis Hollow, 13 May 1997, *Brant 3696* (MO**); Rocky Creek Falls, 24 Apr 1983, *Merriott 61* (MICH*). **NEW JERSEY. Burlington Co.:** Bordentown, along Crosswicks Creek, 27 Apr 1910, *Long 3103* (NY**). **[Gloucester Co.]:** Swedesboro, 25 Apr 1917, *Mackenzie 7559* (NY**). **Sussex Co.:** Andover Township, SW of Lake Mohawk, just N of Route 613, 0.5 mi by road W of junction with Route 617, 4 May 2004, *Werier 2191* (BH**, MICH, NY); Stokes State Park, S of county Route 636, 0.25 mi E of US Route 206, 4 May 2004, *Werier 2194* (BH*, MICH, NY). **[Warren Co.]:** between Pike and Pequest River ca. 1/4 to 3/8 mi E by slightly NE of Buttsville, 18 May 1919, *Pretz 9602* (PH**). **NEW YORK. New York Co.:** Manhattan Island, Inwood, 27 May 1893, *Bicknell 1237* (NY**). **Orange Co.:** Town of Warwick, SE end of Bellvale Mountain, N of the village of Greenwood Lake, SW of Route 17A, 7 May 2003, *Werier 1507 & Barbour* (BH*). **Ulster Co.:** Town of Saugerties, 1.0 km E of Old Dutch Road, 1.1 mi S by road from Route 32, 22 May 2006, *Werier 2981, Barbour & Barbour* (BH). **NORTH CAROLINA. Davidson Co.:** 1 mi E of Yadkin River near NC 49, 7 Apr 1956, *Radford 9476* (NCU**); S of Route 49, 0.6 mi E of bridge over Yadkin River, 14 Apr 2004, *Werier 1995* (BH*, MICH), *Werier 2000* (BH**, MICH, NCU), *Werier 2001* (BH**, MICH). **Macon Co.:** Nantahala National Forest, ca. 5 mi E of Franklin, then 5 mi N of Ellijay Road, 16 Apr 2000, *Hyatt, Hyatt, & McMillan 9112* (MICH**); W of Ellijay Road and Ellijay Creek, 3.7 mi by road NE from Route 64, 19 Apr 2004, *Werier 2048* (BH*, MICH, NCU); E of Route 2, 5.4 mi by road NE from Route 64, 19 Apr 2004, *Werier 2052* (BH**, DOV, MICH). **Madison Co.:** 0.5 mi WNW of Marshall on NE side of French Broad River, 26 Apr 1958, *Ahles 38966 & Duke* (NCU**). **Mecklenberg Co.:** 2.4 mi SE of Davidson on NC 73, 22 Apr 1958, *Ahles 38691 & Britt* (NCU**). **Orange Co.:** Phills Creek, N side, 3 mi W of Chapel Hill, 18 Apr 1940, *Radford & Stewart 469a* (NCU**). **Swain Co.:** Nantahala National Forest, Wessen vicinity, S side of US Hwy. 19, 10 Apr 2000, *Hyatt 9071* (MICH**). **PENNSYLVANIA. Berks Co.:** 5/8 mi ENE of Walnut & 14th Street, Reading, 20 May 1943, *Berkheimer 3563* (NYS*). **[Lancaster Co.]:** Lancaster, [no date], [no collector] s.n. (MICH**); [no location information], [no date], [*Muhlenberg?*] *s.n.* (PH**); [no location information], [no date], Muhlenberg s.n. (PH**). **RHODE ISLAND. [Washington Co.]:** South Kingston, 13 May 1877, *Congdon 1776* (NY**). **SOUTH CAROLINA. Chester Co.:** near Catawba River at Great Falls, 15 Apr 1961, *Radford 43511* (NCU**). **Chesterfield Co.:** W of Catarrh, just E of Lynches River, and just S of Route 903, 17 Apr 2004, *Werier 2013* (BH*, MICH). **Fairfield Co.:** 2 mi NE of Altston, 15 Apr 1961, *Radford 43473* (NCU**). **Greenville Co.:** E of Marietta, small road, 20 m SE from Route 414, 2.1 mi by road NE from Route 276, 18 Apr 2004, *Werier 2029* (BH**, MICH). **Horry Co.:** 2 mi S of Myrtle Beach, 18 Apr 1932, *Weatherby & Griscom 16461* (PH**, US**). **Lancaster Co.:** near Catawba River, 2 mi NE of Great Falls, 15 Apr 1961, *Radford 43524* (NCU**); E of Great Falls and a little bit E of the Catawba River, 17 Apr 2004, *Werier 2023* (BH**, MICH), *Werier 2027* (BH**); E of US 601, S side of Flat Creek, 21 Apr 1961, *Williamson F138 & Ahles* (NCU**), 16 Apr 2004, *Werier 2010* (BH*, MICH). **Pickens Co.:** SC Department of Natural Resources eastern tract of Lake Jocassee, S of Mill Creek entrance, 19 May 1998, *Waldrop W-274 & Townsend* (MICH**); just E of tributary to Oolenoy River and SSR 69, 0.1 mi by road N from Route 288, 2.5 mi by road E from Route 178, 18 Apr 2004, *Werier 2038* (BH**, MICH), *Werier 2041* (BH**, DOV NCU). **TENNESSEE. Franklin Co.:** 2.6 road mi S of Huntland, along E side of Route 97, 2.6 road mi S of junction of Routes 97 and 122, 24 May 1998, *Naczi 7249 & Ford* (VPI**). **Grundy Co.:** just NW of state Route 50 (Elk Head Rd.), 5.7 mi by road SW from junction with Route 108, 22 Apr 2004, *Werier 2087* (BH*, MICH); E of Route 56 at hair pin turn, 6.6 mi by road S from Warren Co. line, 22 Apr 2004, *Werier 2098* (BH**, MICH). **Jackson Co.:** W side of the Cumberland River at its junction with Cub Creek, 19 Apr 1998, *Phillippe 29579* (MICH**); NE of Cub Creek just before junction with Cumberland River, 23 Apr 2004, *Werier 2102* (BH**, MICH). **[Jefferson Co.]:** French Broad River, near Dandridge, 1844, *Rugel s.n.* (MO**, NY**). **[Knox Co.]:** Knoxville, Cherokee Bluffs, 9 Apr 1930, *Underwood 5* (GH**). **Marion Co.:** S end of Little Cedar Mountain, W side of Nickajack Lake, and 2.8 km N of Interstate 24 bridge W of Haletown, 8 Apr 2000, *Wieboldt 10418* (MICH**, VPI); E slope of Little Cedar Mountain, ca. 3.5 km N of interstate 24 bridge over Nickajack Lake, NNW of Haletown, 8 Apr 2000, *Wieboldt 10423* (MICH**, VPI). **Maury Co.:** bluffs of Duck River ca. 2.5 mi SE of Columbia and 1.2 mi E on Sowell Pike from TN 50, 13 Apr 1974, *Kral 42463* (BRIT**, MO). **Polk Co.:** N of Ocoee Lake and Route 64, 1.7 mi W of junction with Route 314, 20 Apr 2004, *Werier 2062* (BH*), 20 Apr 2004, *Werier 2063* (BH**, MICH). **Putnam Co.:** bluffs along Caney Fork River by I-40, 10 Apr 1992, *Kral 80112*

& Moore (BRIT**). **Rutherford Co.:** just N of Luvergne, 9 Apr 1976, *Kral 57547* (BRIT**, MO). **Sevier Co.:** N of Little Cove Creek Road, 4.8 mi by road E of Wear Valley Road, 27 Apr 2004, *Werier 2132* (BH**, MICH). **VIRGINIA. Accomack Co.:** S side of road to Sinnickson, 18 Apr 1999, *McAvoy 4266* (DOV**). **Albemarle Co.:** Mount Alto, near Howardsville, 21 Apr 1973, *Stevens 6523* (NCU**), 21 Apr 1973, *Stevens 6525* (NCU**). **[Albemarle Co.]:** Monticello Mountain, the Grove, 21 Apr 1980, *Wieboldt M-26* (PH**). **Alleghany Co.:** N of Route 18, N of small creek which is a tributary of Potts Creek, 0.6 mi by road S from Route 657, 30 Apr 2004, *Werier 2153* (BH**, DOV, MICH, VPI), 30 Apr 2004, *Werier 2155* (BH**); 30 Apr 2004, *Werier 2156* (BH**, MICH, VPI). **Botetourt Co.:** NW of Route 615, 0.7 mi by road N of junction with Craig Co. line, 29 Apr 2004, *Werier 2143* (BH**, MICH, MO, NCU, VPI), 29 Apr 2004, *Werier 2146* (BH**). **Brunswick Co.:** along Hwy. 670, 2.3 mi NE of its junction with Hwy. 46, 2 May 1986, *Rettig 1523* (NYS**); Route 670, 2.2 to 2.3 mi by road N of Route 46, 11 Apr 2004, *Werier 1983* (BH**, MICH, VPI); along Hwy. 712, 7.6 mi N of its junction with Hwy. 58 in Edgerton, 2 May 1986, *Rettig 1525* (MO, NYS**); 7.7 to 7.8 mi by road N of Route 712 from Route 58 in Edgerton, 11 Apr 2004, *Werier 1972* (BH**, MICH, VPI), *Werier 1979* (BH**). **Buckingham Co.:** small tributary of David Creek, ca. 1 mi NE of Bent Creek, 9 May 1983, *Wieboldt 4635 & Britten* (MO**, VPI). **Caroline Co.:** near North Anna River, 10 Apr 2004, *Werier 1954* (BH**), *Werier 1958* (BH**), *Werier 1960* (BH**, MICH), *Werier 1961* (BH**, MICH). **Chesterfield Co.:** 7 mi WNW of Winterpock, along S side of Route 360, 0.2 mi E of Appomattox River, 30 Apr 2005, *Naczi 10792* (BH, DOV**, MICH). **Culpepper Co.:** 2nd peak, Buzzard Mountain, 11 May 1941, *Allard 8589* (VPI*). **Fauquier Co.:** C.F. Phelps Wildlife Management Area, ca. 1.9 mi SW from Kelly Ford, E of Rappahannock River., 1 May 2004, *Werier 2168* (BH**, MICH, NCU, VPI). **Henry Co.:** along Smith River about 0.9 mi below state Route 636 bridge and ca. 5 mi NNE of Ridgeway, 28 Apr 1987, *Wieboldt 6301 & Wieboldt* (VPI**). **Isle of Wright Co.:** near Walters, 6 Apr 1938, *Fernald & Long 7775* (GH, PH**). **King George Co.:** 2 mi SSW of Owens, along E side of Route 301, 1.5 mi SW of its junction with Route 218, 29 Apr 2005, *Naczi 10778* (BH, DOV**). **Montgomery Co.:** N of state Route 637 at NW end of Coffee Valley, ca. 7 km E of Ellett, 11 May 1993, *Wieboldt 8509, Ludwig, Rawinski, et al.* (DOV**, MICH**, VPI); N of Coffee Hollow at NW end of hollow, NE of Seneca Hollow Road, 28 Apr 2004, *Werier 2138 & Wieldboldt* (BH**, MICH). **New Kent Co.:** 4 mi N of Barhamsville, along E side of Route 33, 0.5 mi SW of its junction with Route 273, 1 May 2005, *Naczi 10822* (BH, DOV**, MICH). **Newport News City:** behind baseball field on Monroe, Fort Eustis, 22 Apr 1974, *Appler 1064 & Wieboldt* (NCU). **Patrick Co.:** along Spoon Creek ca. 10 mi SE of Stuart, 27 Apr 1983, *Wieboldt 4619* (MO**, VPI). **Pittsylvania Co.:** along N-facing bluff of the Staunton River ca. 4 mi N of Straightstone, 23 Apr 1985, *Wieboldt 5472* (MICH**, VPI); Boyd Mountain, ca. 3 km NE of Leaksville Junction on Southern Railroad, 28 Apr 1993, *Wieboldt 8454* (DOV**, MICH**, VPI). **Powhatan Co.:** Powhatan State Wildlife Management Area, NW of Macon, 11 Apr 2004, *Werier 1964* (BH**, MICH), *Werier 1968* (BH**, MICH, VPI). **Prince Edward Co.:** 7 mi SSW of Farmville, along tributary of Briery Creek, ca. 0.3 mi N of dam of Briery Creek Lake, S of road 790, 30 Apr 2005, *Naczi 10811A* (DOV**). **Prince George Co.:** Coggins Point, 4 Apr 1939, *Fernald & Long 9699* (GH, PH**). **Shenandoah Co.:** S end of Short Mountain, Massanuttens, ca. 3 mi SE of Mount Jackson, 1 May 1982, *Wieboldt 4284 & Davenport* (VPI**). **Southampton Co.:** by the Nottoway River near Davis School, Indian Road, NW of Courtland, 4 Apr 1940, *Fernald, Long, & Pease 11654* (GH**, PH**). **Surry Co.:** W of Claremont, 19 Apr 1942, *Fernald, Long, & Abbe 14117* (GH, PH**); ca. 1/2 mi NE of reactors at VEPCO Surry Nuclear Power Station, 13 Apr 1974, *Ware 5391 & Wieboldt* (NCU). **Sussex Co.:** 4 mi S of Stony Creek, 5 Apr 1937, *Fernald & Long 6952* (GH, PH**). **Wythe Co.:** Rock Creek 2.6 km E of community of Cripple Creek, 6 May 2004, *Wieboldt 11390* (VPI**).

APPENDIX A

Specimens of *Carex nigromarginata* measured for the ordination (Fig. 3) are marked with a single asterisk; the ones marked with a single or double asterisk were measured for the scatter plot graph and character distribution curves (Fig. 4, 5, and 6).

CANADA. ONTARIO. Norfolk Co.: Long Point, Squires Ridge, 10 1/2 to 13 mi from base of point, 25 May 1980, *Reznicek 5496* (MICH**); Long Point, middle of Little Creek Ridges to Gravelly Bay, 15 to 19 mi from base of point, 15 Jun 1980, *Reznicek 5636* (MICH**). **U.S.A. ALABAMA. Autauga Co.:** Autauga County 9, W of Ivy Creek, ca. 0.5 mi E of junction with Autauga County 15, 16 Apr 1980, *Wiersema 1537* (BRIT**). **Butler Co.:** by county 59, N of Pigeon Creek, 11 Mar 1991, *Kral 78407* (BRIT**); by I-65, 4 mi N of exit to AL 106, 26 Mar 2002, *Kral 92214* (BRIT**). **Dallas Co.:** ca. 1 mi WNW of Cahaba, 31 Mar 1972, *Kral 45340* (BRIT**). **Escambia Co.:** N side of Route 55, ca. 0.5 mi W of Route 41, 19 Mar [19]82, *Wilhelm 10013* (BRIT**). **Jackson Co.:** just E of Route 35, 0.1 mi S of junction with Route 40, 21 Apr 2004, *Werier 2072* (BH*); off of county Route 33, 8.05 mi by road SE of junction with Route 79, 21 Apr 2004, *Werier 2079* (BH**). **Monroe Co.:** E bank of Alabama River above landing at Haines Island, 15 Apr 1980, *Wiersema 1482* (BRIT**). **Morgan Co.:** by US 31, 1 mi. S of Lacon, 12 Apr 1970, *Kral 38342* (BRIT**). **Perry Co.:** Hwy. 219, 3.0 mi S of Bibb County line, 9 Apr 1986, *Rettig 1443* (BRIT**). **ARKANSAS. Bradley Co.:** Warren Prairie Natu-

ral Area, SE of Warren, 17 Apr 1986, *Rettig 1494* (MO**); Warren Prairie, ca. 15 mi W of Monticello, 3 Apr 1983, *Sundell 2962* (BRIT**); about 1 mi W of Hermitage, 18 Mar 1995, *Hyatt 6161* (MICH**). **Calhoun Co.:** Hwy. 160 about 2 mi W of Bradley County, 18 Mar 1995, *Hyatt 6166* (MICH**). **Clark Co.:** Caddo Valley vicinity, 1 May 1995, *Hyatt 7023* (MICH**). **Columbia Co.:** US Hwy. 79 at Ouachita County line, 18 Mar 1995, Hyatt 6173 (MICH**). **Crawford Co.:** just S of Rudy, 20 Apr 1985, *Castaner 8218* (MO*); Road 220 just S of Lee's Creek, 20 Apr 1985, *Castaner 8224* (MO**). **Drew Co.:** Monticello, A. & M. College Farm, 21 Apr 1937, *Demaree 14558* (MICH**); 2.8 mi S of Lincoln County on US Hwy. 425, 29 Mar 1997, *Hyatt 7287* (MICH**). **[Garland] Co.:** Hot Springs National Park, Mar 1930, *Connell s.n.* (MO*). **Howard Co.:** Saline River at its junction with Hwy. 84, 15 Apr 1986, *Rettig 1474* (MO**). **Miller Co.:** along Hwy. 237, 0.7 mi N of its junction with Hwy. 160, 14 Apr 1986, *Rettig 1470* (BH**); Hwy. 237, 0.3 mi S of junction with Hwy. 134, 14 Apr 1986, *Rettig 1472* (BRIT**). **Nevada Co.:** AR Hwy. 4 at Ouachita County line, 18 Mar 1995, *Hyatt 6172* (MICH**); by I-30, 3.3 mi SW of junction with AR 26, 16 Apr 1999, *Kral 88225* (BRIT**). **Ouachita Co.:** NW of Camden, AR Hwy. 4 loop, 1.6 mi E of AR Hwy. 376 junction, 18 Mar 1995, *Hyatt 6169* (MICH**). **Pike Co.:** 0.3 mi S of Montgomery County on AR Hwy. 369, 15 Apr 1996, *Hyatt 6938* (MICH**). **Polk Co.:** Ouachita National Forest, Along Forest Service Road 38 to Shady Lake, 3.2 mi N of its junction with Hwy. 246, 15 Apr 1986, *Rettig 1477* (MO**); Ouachita National Forest, along Forest Service Road 38, 1.0 mi N of entrance to Shady Lake at junction with Forest Service Road 508, 15 Apr 1986, *Rettig 1480* (MO**). **Pope Co.:** Long Pool Recreation Area, Ozark National Forest, above Big Piney Creek, 16 Apr 1986, *Rettig 1491* (MO*). **Sevier Co.:** Saratoga Community, 15 Apr 1996, *Hyatt 6307* (MICH**); DeQueen, 1.9 mi N on US Hwy. 71, 23 Apr 1995, *Hyatt 6949* (MICH**). **Scott Co.:** Ouachita National Forest, approximately 5.5 mi S, 1.5 mi E of junction of Hwy. 80 and business loop Hwy. 71 in Waldron, 9 Apr 1999, *Morse 2843* (BRIT**); Ouachita National Forest, approximately 2.5 mi S, 3.0 mi W of Boles, 10 Apr 1999, *Morse 2904* (BRIT**). **Sharp Co.:** N of Cave City on 167, 2 mi S of junction with 167/56, 6 May 1979, *Castaner 5667* (MO*). **Stone Co.:** Ozark National Forest, Sylamore District, T16N, R11W, S15, NW4 of NW4, 27 Apr 1993, *Hyatt 5251* (MO*). **Union Co.:** S of El Dorado, at a roadside park/welcome center 5.7 mi N of Louisiana on US Hwy. 167, 18 Mar 1995, *Hyatt 6159* (MICH**). **DELAWARE. [NewCastle Co.]:** Newcastle, [no date], *Canby s.n.* (BH*). **DISTRICT OF COLUMBIA. [Washington Co.]:** Brookland, 14 May 1899, *Holm s.n.* (MO*); Wasnington, [no date], *Vasey 187* (BH**). **FLORIDA. Gadsden Co.:** near Flat Creek, general vicinity of Sycamore, 6 Mar 1977, *Godfrey 75723* (BRIT**); N of FL Route 20 between Ochlockonee River and Hosford, 15 Mar 1975, *Godfrey 74186* (BRIT**). **Liberty Co.:** ca. 6 mi NE of Bristol, N of Route 12 just W of its junction with Route 271, 14 Mar 1994, *Naczi 3620* (BRIT**). **GEORGIA. Clarke Co.:** near Winterville, 2 Mar 1929, *Miller & Maguire 297* (BH**); GA State College Agricultural Farm, 9 Mar 1929, *Miller & Maguire 298* (BH**); Princeton Woods, S side of Oconee River, 6 Apr 1929, *Miller & Maguire 300* (BH*). **Dade Co.:** E side of Route 136, 3.55 mi by road NW of junction with Route 189, 20 Apr 2004, *Werier 2067* (BH**). **Lincoln Co.:** near summit of Graves Mountain, 5 Apr 1939, *Clausen & Trapido 3794* (BH*). **Rabun Co.:** SE of Glade Mountain, 17 Apr 1949, *Smith & Duncan 9333* (BH**). **Upson Co.:** Dripping Rocks, 30 Mar 1948, *Smith et al. 3667* (BH**). **ILLINOIS. Alexander Co.:** Shawnee National Forest, Jonesboro Ranger District, Compartment J 104, 5 May 1994, *Phillippe 23977* (MICH**). **Union Co.:** Ozark Hill Prairie Research Natural Area, Shawnee National Forest, 8 Apr 1992, *Phillippe 19778* (MICH**). **KENTUCKY. Grayson Co.:** along Hwy. 411, 0.4 mi E from Hwy. 85, 27 Apr 1987, *McKinney 2473* (BRIT*). **Lawrence Co.:** above state Route 1690, 0.6-0.8 mi NE of junction of Benbow Road, 12 Apr 1990, *Cusick 28744* (BRIT*). **LOUISIANA. Caddo Parish:** State Line Road 14.8 mi S of junction with Hwy. 171, 13 Apr 1986, *Rettig 1457* (MO**). **Claiborne Parish:** Kisatchie National Forest Caney Ranger district, 10 Apr 1996, *Hyatt 6876* (MICH**). **Grant Parish:** Kisatchie National Forest Catahoula Ranger district, 6 Mar 1995, *Hyatt 6151* (MICH**); Kisatchie National Forest, about 3 mi NE of Williana, 3 Mar 1997, *Hyatt 7865* (MO**); Dry Prong community vicinity, 22 Apr 1996, *Hyatt 6857* (MICH**). **Morehouse Parish:** S of LA 835 by Bryant Main Line Road then E to end of Kitpatrick Road, 30 Apr 1992, *Bryson 11441* (MICH**). **Natchitoches Parish:** Kisachie National Forest, ca. 1 mi SE of Goldonna at Saline Bayou on LA Hwy. 156, 24 Feb 1998, *Hyatt 7860* (MO**); Kisatchie National Forest, Kisatchie Ranger district, compartment 4, 10 Mar 1998, *Hyatt 7872* (MICH**). **Ouachita Parish:** 3 mi SW Cheniere, 11 Apr 1959, *Kral 8510* (BRIT**). **Rapides Parish:** Brushy Creek Riparian Site, 23 Mar 1998, *Hyatt 7913* (MICH**). **Sabine Parish:** LA 175 at Pleasant Hill, 3 Oct 1967, *Thomas 5635* (BRIT**). **Union Parish:** Hwy. 2, 7.7 mi E of Hwy. 33/15 in Farmerville, 11 Apr 1986, *Rettig 1456* (BRIT**). **MARYLAND. Baltimore Co.:** Summerfield, 7 mi NE of Baltimore, 5 May 1910, *Churchill s.n.* (BH**). **Caroline Co.:** Tuckahoe State Park, W of Cherry Lane, 1.2 mi S from junction with Mason Branch Road, 2 May 2004, *Werier 2177* (BH*), *Werier 2179* (BH**). **Montgomery Co.:** Great Falls, 30 May 1917, *VanEseltine 1302* (BH**). **Prince George Co.:** near Congress Heights, 25 May 1915, *VanEseltine 385* (BH**). **MISSISSIPPI. Attala Co.:** 5.5 mi SSE of McCool, 12 Apr 1986, *Bryson 4152* (MO**); 2.6 mi SSE of Attala Carroll County line along MS Hwy. 35, 12 Apr 1986, *Bryson 4138* (MO**). **Holmes Co.:** Holmes County State Park, 16 Mar 1968, *McDaniel 10376* (BRIT**). **Kemper Co.:** White Horse Mountain, ca. 10.5 air mi N of Dekalb, 6 Apr 1972, *McDaniel 15865* (BRIT**). **Lafayette Co.:** 4.2 mi S of intersection of MS Hwys. 7 and 6 bypass, s of Oxford, 9 Apr 1987, *Bryson 5327* (MO*). **Leake Co.:** near Yockanookany Creek, ca.

8 mi WSW Carthage, 2 Apr 1972, *McDaniel 15819* (BRIT**). **Oktibbeha Co.:** 0.5 mi NW of Sturgis, Hannah Hill, 20 Apr 1989, *Bryson 8463* (MO*). **Winston Co.:** W Betheden Lutheran Church, 6 Mar 1974, *Bryson 318* (BRIT**); 2.5 mi NE Louisville, 6 Mar 1974, *Bryson 317* (BRIT**). **MISSOURI. Butler Co.:** Poplar Bluff Bottomland Hardwood Natural Area, 24 Apr 1982, *Castaner 6749* (MO*). **Callaway Co.:** 0.25 mi E of Williamsville, 25 Apr 1997, *Summers & Vanderbilt 8062* (MO**). **Carter Co.:** Mark Twain National Forest, 3 mi S of Van Buren off Hwy. 103 in Spring Valley, 6 May 1995, *Summers & Wallace 7334* (MO*). **Laclede Co.:** Mark Twain National Forest, Gasconade River, 2 mi W of Adam Ford, 24 Jun 1995, *Summers 7460* (MO**). **Madison Co.:** 8 mi S of Twelve Mile Creek, along Hwy. 67, 26 Apr 1987, *Castaner 9602* (MO*). **Shannon Co.:** Middle Hollow, 7 May 1997, *Brant 3687* (MO*). **Ste. Genevieve Co.:** Hickory Canyon Natural Area, ca. 2 mi N of Sprott on Hwy. EE, 23 May 1996, *Summers et al. 7800* (MO**); Pickle Springs Natural Area, ca. 0.25 mi E of Hwy. AA, ca. 1.5 mi SE of Hwy. 32, 20 Apr 1996, *Summers et al. 7695* (MO**). **Wayne Co.:** Mark Twain National Forest, 2 Apr 1998, *Brant 3882* (MO*). **NEW JERSEY. Somerset Co.:** Chimney Rock, Bound Brook, May 1935, *Edwards s.n.* (BH**). **[Gloucester Co.]:** Newfield, 20 May 1873, *Ellis s.n.* (BH**). **NEW YORK. Orange Co.:** Town of Warwick, SE end of Bellvale Mountain, N of village of Greenwood Lake, SW of Route 17A, 7 May 2003, *Werier 1506 and Barbour* (BH*). **NORTH CAROLINA. Davidson Co.:** a little E of Tuckertown Road, 1.5 mi by road S of Route 49, 14 Apr 2004, *Werier 1992* (BH**), *Werier 1993* (BH*), *Werier 1994* (BH**); S of Route 49, 0.6 mi E of bridge over Yadkin River, 14 Apr 2004, *Werier 1996* (BH**). **Montgomery Co.:** Flint Hill Road, ca. 2.5 mi by road W of Lovejoy Road, 13 Apr 2004, *Werier 1986* (BH**). **Swain Co.:** 100 yards inside Graham-Swain County line on US 129, 11 Apr 1983, *Reznicek 7132* (MO*); SE of Route 19 at junction of Route 28, 26 Apr 2004, *Werier 2128* (BH**). **Transylvania Co.:** N side of Route 64 just E of Lake Toxaway, 18 Apr 2004, *Werier 2044* (BH**). **OHIO. Gallia Co.:** Symmes Creek Road, 1.25 mi S of Gallia Centerpoint Road, 9 Apr 1986, *Cusick 25054* (MICH**). **Jackson Co.:** Camp Canter's Cave, N of Caves Road, 16 Apr 1990, *Cusick 28752* (MICH**). **Scioto Co.:** N side of Dark Lick Road 3/4 mi E of Disterdick Road, 19 Apr 1990, *McCormack 2094* (MICH**). **OKLAHOMA. LeFlore Co.:** 3 mi W on SH 63 and 0.5 N of Arkansas/Oklahoma state line, 4 Apr 1992, *Magrath 18592* (MICH**); W side OK Hwy. 144 2.1 mi SE of Little River bridge at Honobia, 19 May 1993, *Reznicek 9353* (MICH**). **PENNSYLVANIA. Bedford Co.:** 0.75 mi WSW of Breezewood, 16 May 1946, *Berkheimer 7110* (BRIT**). **Berks Co.:** Robeson Township, N side of outlet from Birdsboro Reservoir, 3 May 2004, *Werier 2185* (BH**). **[Carbon Co.]:** ca. 1/8 mi W of Lehigh Gap L.V.R.R. station, 22 May 1927, *Pretz 12925* (BH**). **Centre Co.:** Ingleby, 2 mi E of Coburn, 5 May 1936, *[Wahl] 2486* (BH**); Ingleby, 6 Jun 1937, *Clausen & Wahl 2528* (BH**); abandoned railroad at Ingleby, 7 May 1977, *Keener 3401* (MO**). **Huntingdon Co.:** ca. 2.5 mi E of McAlevys Fort, 29 May 1979, *Lahham & Keener 15* (BRIT**). **Potter Co.:** Town of Pike, N of US Route 6, ca. 0.5 mi NW of Galeton, 26 May 2005, *Werier 2546* (BH*). **SOUTH CAROLINA. Anderson Co.:** 2 mi SE of Savoy Springs, 6 Apr 1939, *Clausen & Trapido 3805* (BH**). **Chesterfield Co.:** N side of Route 9, W of Thompson Creek, W of Zoar Road, 15 Apr 2004, *Werier 2003* (BH**). **Darlington Co.:** Society Hill, [no date], *Curtis 106* (BH**). **[Darlington Co.]:** W of Hartsville, 9 Apr 1921, *Norton C21* (BH), *Norton s.n.* (BH**). **Greenville Co.:** 20 meters SE from Route 414, 2.1 mi by road NE from Route 276, 18 Apr 2004, *Werier 2028* (BH*). **Lancaster Co.:** E of Route 601, S of Flat Creek, 16 Apr 2004, *Werier 2011* (BH**); E of Great Falls and a little bit E of the Catawba River, 17 Apr 2004, *Werier 2024* (BH**). **Oconee Co.:** SE side of Stump House Mountain, 7 Apr 1939, *Clausen & Trapido 3811* (BH**). **Pickens Co.:** just N of Route 288, 1.2 mi by road E of Pumpkintown and Route 8, 18 Apr 2004, *Werier 2031* (BH**), *Werier 2034* (BH**), *Werier 2035* (BH**); just E of SSR 69, 0.1 mi by road N from Route 288, 2.5 mi by road E from Route 178, 18 Apr 2004, *Werier 2039* (BH*). **TENNESSEE. Davidson Co.:** Dyer Observatory, 30 Mar 1976, *Kral 57466* (MO*). **Grundy Co.:** NW of state Route 50, 5.7 mi by road SW from junction with Route 108, 22 Apr 2004, *Werier 2093* (BH**). **Polk Co.:** N of Route 64, 11.1 mi by road E of junction with Route 314, 20 Apr 2004, *Werier 2059* (BH**). **Sevier Co.:** N of Little Cove Creek Road, 4.8 mi by road E of Wear Valley Road, 27 Apr 2004, *Werier 2134* (BH**). **TEXAS. Cass Co.:** Hwy. 155, 1.5 mi SW of its junction with Hwy. 59 in Linden, 14 Apr 1986, *Rettig 1469* (MO**); 3 mi SE Hughes Springs, 2 Apr 1979, *Kral 63243 and Carter* (BRIT**). **Houston Co.:** FR 227, 0.1 mi NW from junction with Davy Crockett Road (NF 526), 10 Apr 1990, *Jones 4309 and Wipff* (MO**). **Smith Co.:** Tyler State Park, N of Tyler, 13 Apr 1986, *Rettig 1465* (BRIT**). **Upshur Co.:** Hwy. 155, 9.5 mi SW of its junction with Hwy. 259 in Cedar Springs, 14 Apr 1986, *Rettig 1467* (MO**). **VIRGINIA. Botetourt Co.:** NW of Route 615, 0.7 mi by road N of junction with Craig Co. line, 29 Apr 2004, *Werier 2148* (BH**). **Brunswick Co.:** 7.7 to 7.8 mi by road N of Route 712 from Route 58 in Edgerton, 11 Apr 2004, *Werier 1969* (BH**), *Werier 1971* (BH**), *Werier 1975* (BH*); Route 670, 2.2 to 2.3 mi by road N of Route 46, 11 Apr 2004, *Werier 1981* (BH**). **Caroline Co.:** near North Anna River, 10 Apr 2004, *Werier 1952* (BH**), *Werier 1957* (BH**), *Werier 1959* (BH**). **Craig Co.:** Potts Mountain ca. 6 mi NW of New Castle, 18 May 1983, *Wieboldt 4657* (MO*). **Powhatan Co.:** Powhatan State Wildlife Management Area, NW of Macon, 11 Apr 2004, *Werier 1963* (BH**). **WEST VIRGINIA. Mingo Co.:** county Route 3-2, 1 mi SE of county Route 2 at Selwyn, 17 Apr 1991, *Cusick 29399* (MICH**). **Pleasants Co.:** above junction of McKim and Middle Island Creeks, 10 May 1984, *Cusick 23333 and Ortt* (BRIT**). **Ritchie Co.:** county Route 8, 1 1/2 mi S of US Route 50, 8 May 1985, *Cusick & Ortt 24185* (BRIT*). **Tyler Co.:** junction of county Routes 58 and 62 at Fairview Church, 3 May 1989, *Cusick 28021 and Ortt* (BRIT**).

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A NEW SPECIES OF *EUGENIA* (MYRTACEAE) FROM THE MONTEVERDE REGION, COSTA RICA

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ABSTRACT

A new species, **Eugenia haberi** Barrie (Myrtaceae), is described from the Pacific slope in Guanacaste and Puntarenas provinces of Costa Rica. It may be distinguished from *E. rhombea* by characters of the leaves and flowers, especially the calyx. The species is apparently restricted to cliff edges at elevations of 1100 to 1350 meters.

ABSTRACT

Se describe una nueva especie, **Eugenia haberi** Barrie (Myrtaceae), de las provincias de Guanacaste y Puntarenas en el lado pacífico de Costa Rica. Puede diferenciarse de *E. rhombea* por caracteres de las hojas y flores, especialmente el cáliz. La especie está restringida aparentemente a bordes de acantilados a elevaciones de 1100 a 1350 metros.

INTRODUCTION

With about 700 species, *Eugenia* is the largest of the New World genera of Myrtaceae. Forty-nine *Eugenia* are currently known to occur in Costa Rica, including 21 recently described (Barrie 2005) and the species described here. *Eugenia* is characterized by a racemose or fasciculate inflorescence, flowers with an open, four-lobed calyx and an embryo that is an undifferentiated mass of tissue.

Eugenia haberi Barrie, sp. nov. (**Fig. 1**). TYPE: COSTA RICA: PUNTARENAS. Monteverde, Eston's Cliff Edge, 1350 m, 1 Jan 1979 (fl, fr), *W. Haber 263* (HOLOTYPE: MO!; ISOTYPES: MEXU!, MO!, NY!).

Eugenia rhombea (O. Berg) Krug et Urb. aemulans, differt foliis anguste ellipticus, pedicellis brevioribus et lobis calyce minoribus.

Small tree; young growth glabrous or with a few hairs on the margins of the bracts, bracteoles and calyx. Branchlets compressed at the outer nodes; bark reddish brown. Leaves narrowly elliptic, the blades 3–8 × 1–2.5 cm, 2–5 times as long as wide, coriaceous, drying a concolorous green or somewhat darker above, the midvein and margins tan; midvein convex on both surfaces, often with a narrow ridge above; lateral veins 15–20 per side, straight, often obscure above; marginal veins similar to the laterals, straight, ca. 1 mm from the margins; glands numerous on both surfaces, sometimes punctuate above; base narrowly cuneate to weakly concave; margins cartilaginous, decurrent along the petiole; apex acuminate to caudate-acuminate, the tip ultimately rounded; petioles 2–5 mm long, flattened or weakly concave dorsally. Inflorescences axillary, racemose, solitary; axis 1–5 × 1 mm long; flowers 4–10; bracts 0.5 mm in diameter, persistent, circular, the margins scarious, with or without a few hairs; buds 2–3 mm long, ovoid. Flowers pedicellate, the pedicels 4–12 mm long, with prominent pellucid glands; bracteoles 0.7–1 × 0.5 mm, persistent at least through anthesis, ovate, prominently glandular, the base free

MISSOURI
BOTANICAL GARDEN
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HOLOTYPE of: *Eugenia haberi* Barrie

F.R. Barrie 2006

MISSOURI BOTANICAL GARDEN (MO)

COSTA RICA
Puntarenas

Family: MYRTACEAE

Eugenia cf. costaricensis Berg

Monteverde, Eston's cliffedge, 1350 m.

Small tree.

W. Haber 263 2 January 1979.

MISSOURI BOTANICAL GARDEN HERBARIUM (MO)

FIG. 1. Holotype of *Eugenia haberi* Barrie (*Haber 263*, MO).

or slightly connate, the margins entire or scarious, with or without a few hairs; hypanthium 1.5–2 mm long, campanulate; calyx lobes in subequal pairs, 0.7–1 × 0.5 mm, elliptic, prominently glandular, the margins entire or with a few hairs, the apex rounded; petals ca. 4 × 3.5 mm, ovate, the margins with or without a few hairs, the apex rounded; disk 1.2–2 mm in diameter, glabrous; stamens ca. 50, 3–5 mm long; style 5–6 mm long, glabrous. Fruits 6–11 × 6–10 mm, globose or obovoid, mature color black; pericarp thin-walled, glabrous; calyx persistent but reduced.

Eugenia haberi is a small tree found along cliff edges on the Pacific slope in Guanacaste and Puntarenas provinces at elevations of 1100–1350 meters. In many respect it resembles *E. rhombea* (O. Berg) Krug & Urb., a species of coastal areas with a circum-Caribbean distribution. Although *E. rhombea* occurs in both Panama and Nicaragua, it has yet to be found in Costa Rica. The similarities between the two species include general habit, the overall absence of vestiture, with hairs restricted to the margins of the bracts, bracteoles and perianth, and the coriaceous leaves with cartilaginous margins. The two may be differentiated by the shape of the leaves, which in *E. haberi* is narrowly elliptic with a tapering, narrowly cuneate base and an acuminate to caudate-acuminate apex. In *E. rhombea*, the leaves are ovate to elliptic with a rounded or broadly cuneate base and an acute apex. The inflorescences in *E. rhombea* are often superficially fasciculate, and the pedicels of the flowers and fruits are up to 30 mm long. In *E. haberi* the inflorescence rachis may be short but it is apparent and the pedicels do not exceed 12 mm. The calyx lobes of *E. rhombea* are much larger and more prominent, up to 4 mm long and 2 mm wide, and are prominent in flower and fruit, retaining a pale color that contrasts with the dark body of the mature fruit. The calyx persists but is not conspicuous on the fruits of *E. haberi*.

Etymology.—The species is named for Bill Haber, the collector of the type, whose deep and extensive knowledge of the flora and fauna of the Monteverde region is exceeded only by his generosity in sharing the information with others.

Additional collections examined. **COSTA RICA. Guanacaste:** Cantón Liberia, Parque Nacional Guanacaste, Estación Cacao, 1100 m, 10°55'45"N, 85°28'15"W, 22 Nov 1990 (v?) *C. Chávez 391* (INB); Estación Cacao, 7 May 1991, (fr) *C. Chávez 553* (CR, F, INB, MO); Estación Cacao, 11 Apr 1991 (fr), *C. Chávez 541* (CR, INB, MO). **Puntarenas:** Monteverde, Hoge Uppan, 10 Feb 1979 (fl) *W.A. Haber 263* (CR); Monteverde, lower community on Pacific slope, 1350 m, 10°18'N, 84°48'W, 5 Jul 1991 (fr) *W. Haber & C. Ivey 10720* (CR, F, INB).

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Book Notice

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TAXONOMIC REVIEW OF *SYMPHYOTRICHUM PATENS* (ASTERACEAE: ASTEREAE)

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ABSTRACT

The eastern North American *Symphyotrichum patens* has been treated by Jones (1983, 1992) and other botanists to include var. *patens*, var. *patentissimum*, and var. *gracile*. These taxa have been distinguished primarily by habit, involucral size and vestiture, and phyllary orientation. Morphological distinctions between var. *patens* and var. *gracile* have been viewed as overlapping and the two taxa have been interpreted as sympatric over a wide region; the present study concludes that it is not possible to distinguish them in an unarbitrary or evolutionarily meaningful way, and var. *gracile* is not recognized. Variety *patens* sensu lato apparently comprises two diploid and three or four tetraploid population systems. Variety *patentissimum* is morphologically distinct and consistently tetraploid, and it intergrades with tetraploid var. *patens* where their ranges are contiguous or overlapping. A county-level map shows the distribution of the two infraspecific taxa of *S. patens*, as interpreted in the present study. A similar map shows ploidal distribution within the species, based on data available from previous studies.

RESUMEN

Symphyotrichum patens del este de Norte América ha sido tratado por Jones (1983, 1992) y otros botanicos para incluir las var. *patens*, var. *patentissimum*, y var. *gracile*. Estos taxa han sido distinguidos principalmente por el hábito, tamaño involucral y pubescencia, y la orientación de los filarios. Las distinciones morfológicas entre var. *patens* y var. *gracile* ha sido vista como solapada y los dos taxa han sido interpretados comos simpátricos en una región amplia; el presente estudio concluye que no es posible distinguirlos de un moso que no sea arbitrario o en una línea evolutiva significativa, y la var. *gracile* no se reconoce. La variedad *patens* sensu lato comprende aparentemente dos sistemas de poblaciones diploides y tres o cuatro tetraploides. La variedad *patentissimum* es morfológicamente diferente y constantemente tetraploide, y se intergrada con la var. *Patens*, que es tetraploide, allí donde sua areales son contiguos o se solapan. Un mapa a nivel de condado muestra la distribución de los dos taxa infraespecíficos de *S. patens*, tal como se interpretan en el presente estudio. un mapa similar muestra la distribución ploidal de la especie, basado en datos disponibles de estudios previos.

The eastern North American *Symphyotrichum patens* (Aiton) G.L.Nesom has been treated (especially in detail by R.L. Jones 1983, 1992, as *Aster patens*) to include var. *patens*, var. *gracile* (Hook.) G.L.Nesom, and var. *patentissimum* (Lindl.) G.L.Nesom. Infraspecific taxa have been distinguished primarily by habit, involucral size and vestiture, and phyllary orientation. Morphological differences, however, especially between var. *patens* and var. *gracile*, have been construed as overlapping and those taxa have been viewed as broadly sympatric.

Differences among the varieties have been characterized as in the key below, which is amalgamated mostly from contrasts and comments by Cronquist (1980), A.G. Jones (1992), Jones (1983), and Brouillet et al. (2006).

1. Involucres broadly turbinate, 8–12 mm long; phyllaries often in 5–7 series, appressed, obtuse, mid phyllaries ovate-lanceolate, 1.2–1.7 mm wide, densely strigillose to sericeous-strigose, eglandular to sparsely and minutely sessile-glandular _____ var. **patentissimum**
1. Involucres campanulate or slenderly turbinate, 5.0–7.5 mm long; phyllaries in 4-5(-6) series, often at least somewhat squarrose, acute to acuminate, mid phyllaries linear-lanceolate, 0.7–1.2 mm wide, sparsely to densely strigillose, sparsely to densely sessile- or stipitate-glandular.
   2. Plants slender, branches long, conspicuously and minutely bracteate; principal cauline leaves

1 -3(–4) cm long, 0.5–1(–1.5) cm wide; involucres 5.5–6.5(–7.5) mm long; phyllaries sparsely glandular and densely strigillose, mid 0.7–1 mm wide ____ var. **gracile**

2. Plants more robust, branches shorter, with fewer and larger bracts; principal cauline leaves 3–6(–8) cm long, 1–2 cm wide; involucres 6–7.5 mm long; phyllaries densely glandular and sparsely strigillose, mid 1–1.2 mm wide ____ var. **patens**

Variety *patentissimum* occupies a geographic range in the Interior Uplands west of the Mississippi River, except for populations in southern Illinois. Jones (1983) mapped scattered collections of var. *patentissimum* from Texas and Louisiana; Cronquist (1980) included Mississippi in the range. Variety *patens* has been recorded from Maine (Magee & Ahles 1999), New Hampshire, and Masschusetts south to Florida, thence westward to Texas, Oklahoma, and Kansas (Jones 1983). Variety *gracile* was recorded by Jones (1983) in Texas, Oklahoma, Kansas, Missouri, Arkansas, Louisiana, Mississippi, and Alabama — sympatric in each state with var. *patens* and sympatric in Missouri, Arkansas, and Oklahoma with var. *patentissimus*. A.G. Jones (1992) viewed all three taxa as present in Oklahoma. Brouillet et al. (2006, Flora of North America treatment) presented an expanded geographic concept of var. *gracile*, following Cronquist (1980), both of whom recognized its occurrence in Florida, Georgia, South Carolina, North Carolina, Virginia, Tennessee, and Maryland, far into the range of var. *patens*. In the view of both R.L. Jones and of Brouillet et al., the range of var. *gracile* is completely sympatric with that of var. *patens*. Variety *patens* in the concept of Brouillet et al. occurs alone from New Jersey and Delaware northward to Maine and westward from Pennsylvania and New York to Indiana and Illinois.

All chromosome number reports of var. *patentissimum* have been tetraploid ($2n$ = 20). Many populations of var. *patens* (sensu Jones 1983) have been reported as tetraploid (counts from Massachusetts, Illinois, Indiana, New Jersey, Kentucky, Tennessee, Virginia, North Carolina, South Carolina, Georgia, Alabama, and Mississippi); diploids have been reported from western Alabama (Jones 1983; Semple 1984). Variety *gracile* has been recorded at diploid level ($2n$ = 10) in Alabama, Mississippi, Louisiana, Texas, and Oklahoma. Tetraploid counts of var. *gracile* have been reported from Louisiana and Texas (Jones 1983; Semple 1984).

Artificial intervarietal crosses between tetraploids (var. *patens* x var. *patentissimum*) "produced good seed sets, and the hybrid offspring were intermediate in morphology" (Jones 1983, p. 60). Crosses between var. *patens* and *Symphyotrichum phlogifolium* (both tetraploid) were as successful as intervarietal crosses. In contrast, "only a few crosses were attempted between diploid and tetraploid *S. patens*, and none of these were successful" (p. 60).

The concept of *Symphyotrichum patens* in earlier literature has included *S. georgianum* (Alexander) Nesom and *S. phlogifolium* (Muhl. ex Willd.) Nesom, but Jones (1983) elevated these taxa to specific rank, and most later authors, including Brouillet et al. (2006), have followed these concepts, with Cronquist (1980) and Gleason and Cronquist (1991) being notable exceptions. Neither *S. georgianum* nor *S. phlogifolium* intergrades morphologically with other taxa; *S. georgianum* is a decaploid ($2n$ = 50) while *S. phlogifolium* is a tetraploid ($2n$ = 20), and both occur mostly within the geographic range of tetraploid *S. patens* var. *patens*. Another distinct but closely related species, *S. grandifolium* (L.) Nesom, is known only as a dodecaploid ($2n$ = 60). The chromosome counts for these three taxa were first reported by R.L. Jones and A.G. Jones (1979).

The present study reexamines the taxonomic distinctions and geographic distributions of the infraspecific taxa of *Symphyotrichum patens*. The study is primarily based

on specimens examined from BRIT-SMU, MISS, MO, NCU, TEX-LL, and VDB (including many of the collections made by R.L. Jones in his Vanderbilt dissertation study). The collection localities of these are mapped in Figure 1.

Semple (1984) mapped chromosome number reports for *Symphyotrichum patens*, as similarly done here, but the present map (Fig. 2) is more precisely represented and the modified taxonomy gives it a different perspective. Chromosome counts have been made by various botanists but mostly by Semple and Brouillet (1980), Jones (1983), and Semple (1984), as summarized by Semple (1984), with an addition by Jones and Smogor (1984). Several chromosome counts, vouchered by collections by John Semple in 1991 and deposited at TEX and MO, apparently have not been reported in literature: Kentucky, Whitley Co., $2n = 20$ (MO); North Carolina: Wilkes Co., $2n = 20$ (MO); Ohio: Scioto Co., $2n = 20$ (MO); Texas: Harrison Co., $2n = 10$ (TEX) and Fort Bend Co., $2n = 20$ (TEX); West Virginia: Pendleton Co., $2n = 20$ (MO).

RESULTS AND DISCUSSION

Observations of Jones (1983) and of Brouillet et al. (2006) are confirmed here: plants referable to var. *patens* (using criteria as in the key above) occur essentially throughout the range of var. *gracile*, and plants referable to var. *gracile* occur through part of the range of var. *patens*. Map 14A of Jones (1983) indicates that the eastern extension of var. *gracile* is abruptly demarcated along the Mississippi-Alabama border, but the present study has not confirmed this. Typical var. *gracile*-like plants occur northeastward at least into North Carolina. Similarly, collections from Texas and Louisiana resemble plants identified as var. *patens* in Atlantic states. There appears to be a weak east-to-west trend in increase of nonglandular involucral vestiture and, beginning in Alabama westward, development of longer and more bracteate branches, but the present study has not found any geographic zone of morphological discontinuity that would enable or justify the recognition of two taxa. Continued formal recognition of var. *gracile* perpetuates a typological definition. In the present view, recognition of broadly sympatric varieties (as var. *gracile* with var. *patens*) would imply either that the two were reproductively isolated (thus each better treated at specific rank) or else that they represent populational variants (thus not justifiably treated at varietal rank).

Variety *patentissimum* is a distinctive entity. It overlaps in distribution (Fig. 1) with tetraploid var. *patens*, and putative hybrids and introgressants apparently occur in the region of sympatry: Arkansas, Oklahoma, the southwest corner of Kansas, and (east of the Mississippi River) southern Illinois and extreme western Kentucky (intermediates not represented on map). Some measure of reproductive isolation may be active, as typical plants of both taxa have been collected in relatively close proximity in their region of sympatry. Typical var. *patentissimum* occurs as far south as Cleburne and Dallas counties in south-central Arkansas and Sevier and Little River counties in the southwest corner of the state; var. *patentissimum* and var. *patens* and intermediates occur in Craighead and Poinsett counties near the northeast corner of the state.

Plants and populations of var. *patens* sensu lato of different ploidy level do not appear to be intermixed. More counts, of course, might reveal that diploids and tetraploids occur in sympatry, but based on current evidence, diploid populations within var. *patens* apparently occur in two geographic groups, as hypothesized in Fig. 2. Tetraploids apparently occur in four groups (or three groups, if tetraploidy has been derived only once on the east and west sides of the Mississippi River) (Fig. 2). More counts might reveal that

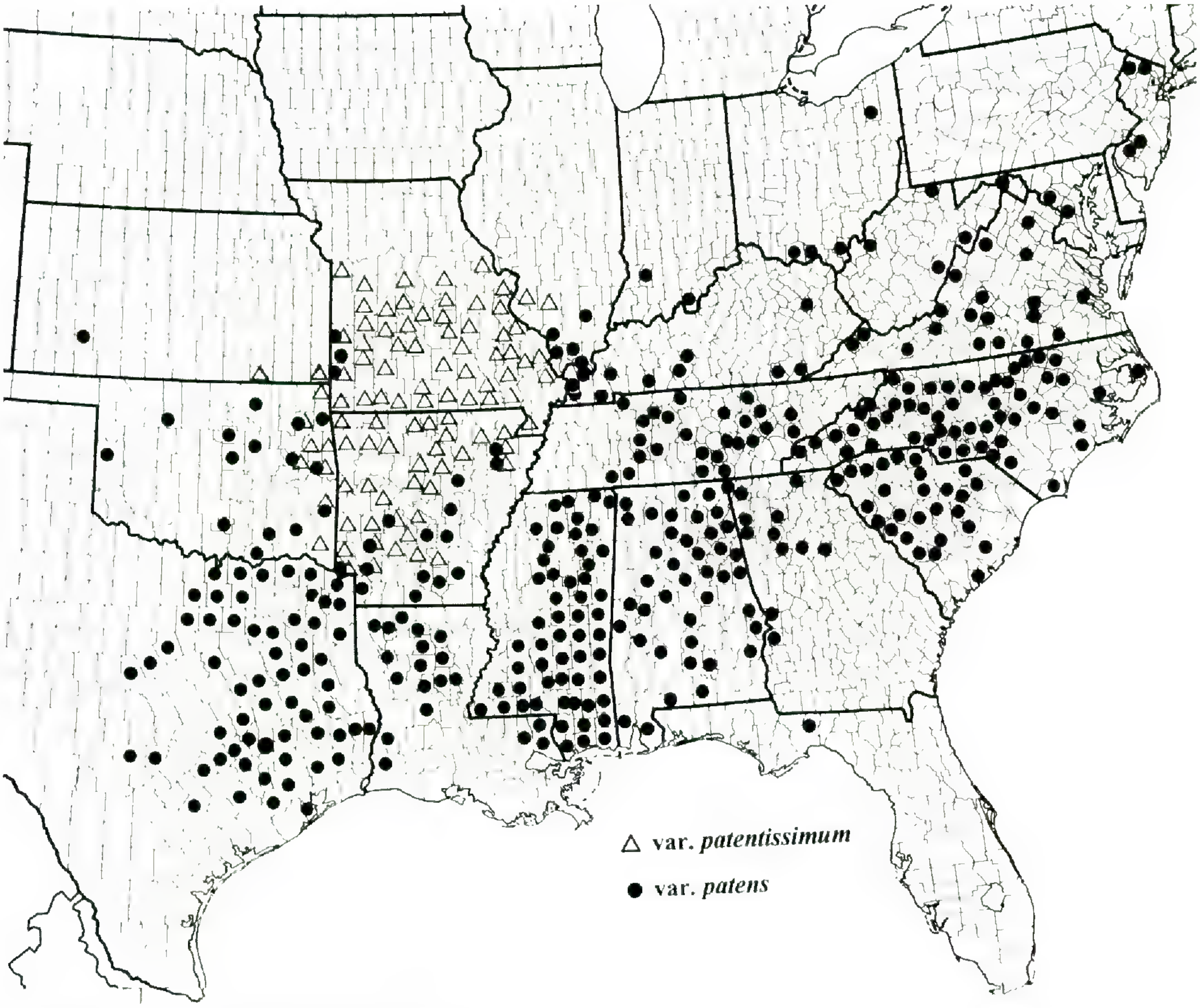


FIG. 1. Distribution of *Symphyotrichum patens* var. *patens* and var. *patentissimum*. Symbols indicate counties from which specimens have been examined in the present study. The record for var. *patens* in Gray Co., Kansas, is fide R.L. Jones (1992); that for var. *patens* in Portage Co., Ohio, is fide Fisher (1988). The range continues northward into Pennsylvania, New York, Rhode Island, Connecticut, New Hampshire, Massachusetts, and Maine.

diploids are continously distributed along the outer coastal plain.

The nomenclatural type (lectotype) of var. *gracile* was collected in Washington Parish, Louisiana, a region where tetraploids, but not diploids, have been found. Morphological or ecological features that might be diagnostic of these population systems of different ploidy level are not apparent. Diploid and tetraploid plants of var. *patens* in Mississippi, for example, as well as in Texas, show similar ranges of morphological variability. Even so, it may be assumed that the ploidal systems within var. *patens* are isolated from adjacent ones by production of triploid hybrids or some other incompatibility (Jones noted that experimental 2x–4x crosses were not "successful").

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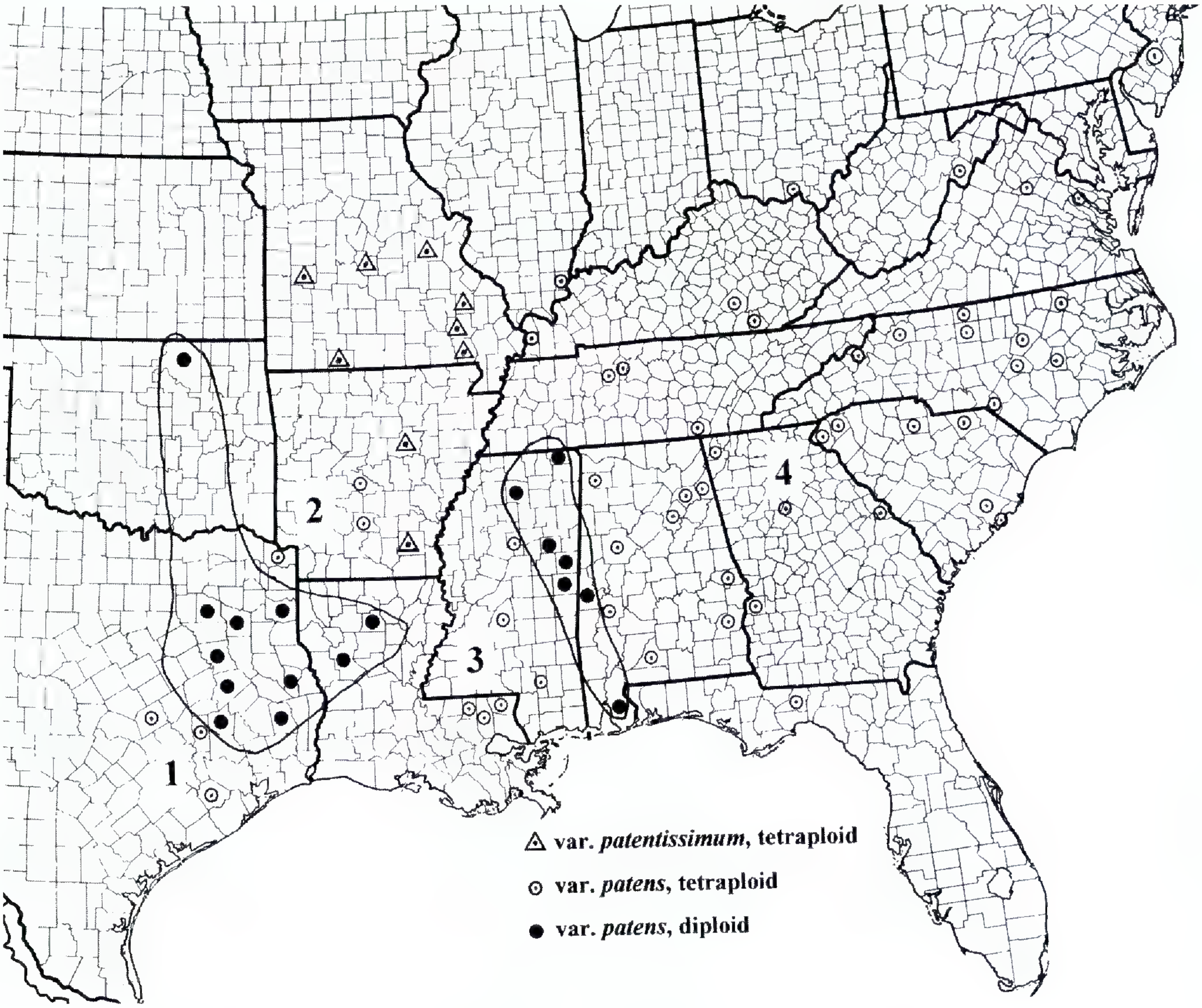


FIG. 2. Distribution of ploidy levels in *Symphyotrichum patens*. Lines enclosing diploid populations indicate the hypothesis that diploids occur in two groups. Tetraploids of var. *patens* thus would be seen as three or four separated population systems (see text).

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DREPANOSTACHYUM FALCATUM VAR. *SENGTEEANUM*: IDENTITY AND ORIGINS (POACEAE: BAMBUSOIDEAE)

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ABSTRACT

Drepanostachyum falcatum var. *sengteeanum* Stapleton, a variety of bamboo thought to have originated from the Himalayas and cultivated in the west for over a century is discussed. The application and the typification of the name under which it was once grown, *Arundinaria falcata* var. *glomerata* Gamble, are considered, along with the application of the name *Arundinaria falcata* Nees. *Arundinaria falcata* var. *glomerata* is lectotypified in accordance with the protologue and current use of the name in India, placing it in synonymy of *Drepanostachyum falcatum* (Nees) Keng f., for which an epitype is designated to support its own incomplete lectotype.

RESUMEN

Se discute *Drepanostachyum falcatum* var. *sengteeanum* Stapleton, una variedad de bambú que se piensa que se originó en el Himalaya y se ha cultivado en el oeste durante más de un siglo. Se consideran la aplicación y la tipificación del nombre bajo el que fue cultivado, *Arundinaria falcata* var. *glomerata* Gamble, junto con la aplicación del nombre *Arundinaria falcata* Nees. Se tipifica *Arundinaria falcata* var. *glomerata* de acuerdo con el protólogo y el uso actual del nombre en la India, colocándolo en la sinonimia de *Drepanostachyum falcatum* (Nees) Keng f., para el que se designa un epitipo para apoyar su lectotipo incompleto.

A bamboo with a prominent and distinctive ring of hairs around the culm sheath base and on the young culm nodes was in cultivation at Kew around 1900, without any record of its provenance. It was misidentified (Bean 1907) as *Arundinaria falcata* Nees var. *glomerata* Gamble, a little-known variety from Uttar Pradesh in the NW Indian Himalaya, described on the basis of a very dubious floral characteristic. *Arundinaria falcata* is curently placed in the genus *Drepanostachyum* Keng f. A bamboo with very similar characteristics started to flower in California in 1994, and its seed has been widely distributed, under different names.

Although initially identified as *Himalayacalamus falconeri*, this graceful Californian bamboo was later distributed as *Drepanostachyum glomeratum* Hort., based on *D. falcatum* var. *glomeratum*, and then as *Drepanostachyum sengteeanum* Hort. It is proving somewhat hardier than all other bamboos in the genus *Drepanostachyum*, and is thus of considerable horticultural merit. It has recently been described as *D. falcatum* var. *sengteeanum* (Stapleton 2006), but a detailed nomenclatural treatment is required for the application of names, *D. falcatum* and *D. falcatum* var. *glomeratum*, to both wild and cultivated plants.

Drepanostachyum falcatum

When describing *Arundinaria falcata*, Nees (1834) cited 'Nepalia' collections made by Royle. Chao and Renvoize (1989) designated a Royle collection labelled 'NW India' from Hooker's Herbarium (K) as lectotype of *Arundinaria falcata*. Although this appears contradictory, no Royle collection from Nepal is extant, and it is actually quite unlikely that Royle or his collectors ever entered Nepal, as they concentrated their collecting activities

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to the north and west of their base in Saharanpur, Uttar Pradesh (Edmondson, pers. comm.). The Himalayan passes further to the east were little-known, except to some 17th Century Jesuits, because of the 'jealous policies' of Chinese and Nepalese powers (Royle 1839).

For identification of species of *Drepanostachyum*, culm sheath characters are critical, but the culm sheaths of *D. falcatum* are not well represented in the original material at K, nor in the Roylean Herbarium (LIV). One small, glabrous culm sheath is present in the lectotype. Munro (1868), Gamble (1896), Tewari (1993) and Negi and Naithani (1994) all record the culm sheath of *D. falcatum* as glabrous, reflecting the characteristics of a large number of later collections, made from Himachal Pradesh to Nepal, with which the lectotype collections agree in other characters. *Drepanostachyum falcatum* in the wild is clearly interpreted as a bamboo with glabrous culm sheaths (which actually have sparse, inconspicuous, white hairs when young).

Plants of *Drepanostachyum falcatum* introduced into western cultivation on different occasions also have essentially glabrous culm sheaths. Stapf (1904) was the first to identify these plants correctly. They were initially cultivated in S Europe as *Bambusa gracilis* A. & C. Riviére, while the name *A. falcata* was misapplied to the hardier species now known as *Himalayacalamus falconeri* (Munro) Keng f., known then as *Arundinaria nobilis* Mitford. Stapf (1904) concluded that early introductions probably came from Naini Tal or Mussoori in Uttar Pradesh around 1840.

The consensus is clear that the name *A. falcata* applies to a species found in the Himalayas from Himachal Pradesh to Kathmandu, and also found in cultivation in Europe, where it was known as *Bambusa gracilis*. This species has almost completely glabrous culm sheaths, although the culm nodes may initially have sparse, short hairs below. A specimen from Uttar Pradesh is selected here as epitype, to support the incomplete Royle lectotype by indicating culm sheath characteristics.

Arundinaria falcata var. _glomerata_ Gamble

Arundinaria falcata var. *glomerata* Gamble was initially distinguished solely on the basis of agglomeration of 3–4 spikelets in close racemes or panicles. This followed an earlier, identical distinction (Munro 1868) between two unnamed developmental forms of *A. falcata*, listed as var. a and var. *b*. Munro clearly explained that these forms merely represented different stages of inflorescence development. He observed that as the season advances branch proliferation leads to compound rather than paniculate forms, with shorter racemes of 3–4 spikelets (var. *b*), totally unlike those seen earlier on younger shoots (var. a). He cited a December collection, *Wallich* 5035 (K-W), from Chisapong, near Kathmandu, Nepal as representative of the later developmental form, var. *b*.

It is not clear whether Gamble (1896) followed Munro's interpretation of the developmental nature of this distinction. Gamble's brief description repeated that of Munro for var. *b*. He indicated in a plate caption that illustrations of var. *glomerata* were from collections made by Bagshawe in 1879. This action was interpreted by Chao and Renvoize (1989) as designation of a type for *A. falcata* var. *glomerata* Gamble, and they cited a Bagshawe collection at K as holotype, albeit a collection made in 1878 not 1879. They listed var. *glomerata* in synonymy of *Sinarundinaria falcata*.

Tewari (1993) subsequently gave the variety full recognition, providing a detailed description attributed to Pandey ined. This, however, differed little from that of the type variety. Culm sheath hairs were not mentioned at all. The description of the culm sheaths

as shining below probably meant having a glossy adaxial, internal surface, rather than being basally glabrous, but there was certainly no mention of any prominent basal ring of hairs. Naithani and Chandra (1998) and Seethalakshmi and Kumar (1998) merely included it in synonymy of *Drepanostachyum falcatum*.

The name *A. falcata* var. *glomerata* has thus been applied to two taxa, one a bamboo of unknown origin cultivated at Kew, the other an Indian bamboo from the borders of Himachal and Uttar Pradesh. The principal diagnostic character of the cultivated plants is a prominent ring of hairs around the base of the culm sheath and the culm node. This is not seen convincingly in any of the collections of wild material. Other characteristics of the cultivated plants include long sparse hairs on only one side of the base of the leaf midrib (costa) rather than both sides, densely scabrous lemmas and paleas, and pubescence only at the tips of rhachilla segments. These characteristics are also not present in the wild material, which therefore cannot be considered the same taxon as the cultivated plants.

Typification of var. *glomerata*

Original material consists of three differently labelled collections at K from Gamble's herbarium, all annotated by him as *Arundinaria falcata* var. *glomerata*. To complicate matters, as is usually the case with older bamboo collections including both fertile and sterile material, these collections represent at least two, and possibly three different species, with mixed collections mounted together on the same sheets.

Only one collection, from Jaunsar Bawa, *Bagshawe s.n.* in 1879, was literally cited in the protologue. The culm nodes and persistent portions of the culm sheath bases are almost completely glabrous.

A second, different collection includes the specimen actually illustrated by Gamble, and this, therefore, can be construed as part of the protologue. This sheet, annotated as type by Chao, is simply labelled '*Comm.* Brandis, Jaunsar'. As 'specimens' collected by Bagshawe' was the citation this could be a further Bagshawe 1879 collection, sent by Brandis. It is clearly mixed, with old, unidentifiable flowers of a *Drepanostachyum* species as well as leaves of a different species, probably *Himalayacalamus falconeri*, with smooth culms, entire leaf sheath ligules and distinguishable tessellation of veins on some of the leaves, which are broader, glabrous, and less cuneate than those of *D. falcatum*.

Gamble dissected spikelets from these two collections. His drawings remain attached to the Bagshawe 1879 collection, with the recognisable spikelets he illustrated remaining in capsules on the two sheets. These drawings were reproduced when describing his var. *glomerata*, but interestingly were used for the plate of the type variety, not that of var. *glomerata*, suggesting that Gamble himself actually had scant regard for any difference between the two varieties.

The third collection from Gamble's herbarium annotated as var. *glomerata*, also from Jaunsar Bawa, but in 1878, is *Bagshawe* 6608. This was cited as holotype of *A. falcata* var. *glomerata* by Chao and Renvoize (1989), and is annotated as type by Renvoize. It again has no culm sheaths, but like the second collection, has some short hairs below the culm node.

To summarise 'specimens collected by C. *Bagshawe*, ... in 1879' was the citation in the protologue. A collection labelled thus is at K. A second, mixed collection, sent by Brandis, was actually illustrated in the protologue, and annotated as type by Chao, while a third collection, *Bagshawe* 6608 in 1878, a date that conflicts with the protologue, was cited as

'holotype' by Chao and Renvoize (1989). The collection cited in the protologue has completely glabrous culm nodes, while the other two collections have distinct, though very short, hairs below the nodes.

It seems more appropriate for the collection bearing the details cited in the protologue to be taken as holotype, rather than the collection stated as 'holotype' by Chao and Renvoize (1989). Although that collection was part of the original material, as it was neither cited nor illustrated in the protologue, their citation of it as holotype cannot be considered an acceptable lectotypification.

The designation here as lectotype of the only sheet actually labelled *Bagshawe*, Jaunsar Bawa, 1879, is in accordance with both the protologue, and with current application of the name in India (Tewari 1993). As the collection actually illustrated in the protologue is recognisable, and citation of *Bagshawe*, 1879 was merely indicating (possibly incorrectly) which collection was illustrated, there would appear to be two elements to consider as syntypes.

The name *D. falcatum* var. *glomeratum* Gamble is misleading, and seems merely to represent a later stage of inflorescence development, as Munro originally intended (1868). There is indeed no separate variety of *D. falcatum* with agglomerated spikelets. It might be considered more appropriate for Gamble to have followed the typification of Munro's earlier unnamed variety. However, *Wallich 5035* is one of the worst bamboo specimens ever preserved in a herbarium, being so decrepit that it has practically no spikelets left at all.

Drepanostachyum falcatum var. *glomeratum*, as interpreted and described in Tewari (1993) and lectotypified here according to the protologue, differs little if at all from the type variety. The precise origin of this type is not known, but it is probably from the same district as the epitype of *D. falcatum* designated here. Culm sheaths are not known, but basal portions remaining attached to the culm nodes of the lectotype are completely glabrous.

Drepanostachyum falcatum (Nees) Keng f., J. Bamboo Res. 2:16. 1983. TYPES: INDIA: 'N.W. India.' *Royle* (LECTOTYPE: K, selected in Chao and Renvoize 1989); INDIA. UTTAR PRADESH: Chakrata, Sep 1898, *Gamble* 27256 (epitype designated here: K)

Arundinaria falcata Nees, Linnaea 9:478. 1834.
Chimonobambusa falcata (Nees) Nakai in, J. Arnold Arbor. 6:151. 1925.
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Sinarundinaria falcata (Nees) C.S. Chao & Renvoize, Kew Bull. 44:357. 1989.
Pleioblastus falcatus (Nees) Nguyen To Quyen, Bot. Zhurn. 75:225. 1990.
Bambusa gracilis A. & C. Riviére, Bull. Soc. Acclim. sér. 3, 5:682. 1878.
Drepanostachyum falcatum (Nees) Keng f. var. *glomerata* Gamble, Ann. Bot. Gard. Calcutta 7:13. 1896; emend. Pandey, D.N. Tewari, Monogr. Bamboo 84. 1993. TYPE: INDIA. UTTAR PRADESH: Jaunsar Bawa, 1879, *Bagshawe* s.n. (LECTOTYPE designated here, K, superseding previous citation of type by Chao & Renvoize, Kew Bull. 44:358. 1989.

Further collections. **INDIA. Uttar Pradesh:** Jaunsar, Aug 1878, *Bagshawe* 6608(K); Jaunsar, *Comm. Brandis* s.n. a (flowers) only, b (leaves) excluded (K).

Drepanostachyum falcatum var. *sengteeanum* and other similar bamboos

Having excluded the name *Drepanostachyum falcatum* var. *glomeratum* from the plants once cultivated at Kew and currently in horticultural use in the USA, it is necessary to consider other possible names.

Arundinaria interrupta Trin. from Nepal has variable development of light, white hairs on the culm nodes, noted in the description. Culm sheaths are not present in the

type, but recent collections from Nepal from a similar location have, in addition to similar white hairs on the culm nodes, the distinctive sparse white hairs on most of the culm sheath and the mainly glabrous culm sheath bases of other collections of *D. falcatum*. Even the lectotype of *A. falcata* has some white hairs on the persistent culm sheath base, and this character was also given in Tewari (1993) for the type variety. The possibility of *Arundinaria interrupta* Trin. representing a separate species was raised (Stapleton 1994), but the new collections suggest that it should remain a synonym of *D. falcatum*.

Other bamboos with hairs at the base of the culm sheath have been collected elsewhere in the Himalayas. *Himalayacalamus fimbriatus* Stapleton also has culm sheaths with a basal ring of hairs and a fimbriate ligule, but the larger stature, the much larger leaves, as well as the asymmetry of the culm sheath with its broader ligule and less scabrous interior distinguish it clearly. *Drepanostachyum annulatum* Stapleton from Bhutan also has a ring of hairs at the base of the culm sheath, but the hairs are darker, longer, more upright and in a narrower ring. That species also differs in having dark brown culm sheath hairs, especially on the distal third of the culm sheath, which also bears erect, basally scabrous oral setae when young, as well as darker brown, longer cilia of up to 1.5mm on the edges. It also has well-developed leaf sheath auricles, and thicker culm wax. In addition the ligules are neither as delicate nor as laciniate, and the culm sheath is less pubescent on the inside at the base of the ligule and below it. Although it shares the possession of a basal ring of culm sheath hairs with *H. fimbriatus* and *D. annulatum*, the bamboo currently cultivated in the US, recently described as *D. falcatum* var. *sengteeanum* (Stapleton 2006) is clearly much closer to the type of *D. falcatum*.

The 2-3 flowered florets and the densely pubescent culm sheath interior apex of var. *sengteeanum* are sufficient to place this cultivated bamboo indisputably in *Drepanostachyum*. The absence of oral setae and the distribution of hairs on the culm sheaths are sufficient to separate it clearly from all previously described taxa. Following current taxonomic concepts in bamboos, culm sheath pubescence and presence of oral setae are important and consistent specific characters. They are usually supported by minor differences in spikelet or floret detail, while leaf sheath and blade characters are inherently more variable. However, in *Drepanostachyum* more variety is seen within species than in most other bamboo genera, and it was felt inappropriate to describe this taxon as a new species, especially as its origin remains unknown. The florets and spikelets of *D. falcatum* var. *sengteeanum* are more scabrous than those of the type variety and the palea is less bifid. The rhachilla segments are slightly longer and have rather different apical pubescence: the beard is mainly restricted to the distal 0.25mm of the rhachilla, while in the type of *D. falcatum* the distal 1mm becomes progressively more puberulent. The lemma and palea are more densely scabrous than any other material of *D. falcatum* from the Western Himalayas, and approach the state seen in other species from the Eastern Himalayas, suggesting a Nepalese or Sikkimese origin.

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REJECTION OF LECTOTYPIFICATION OF *ASTER AMELLUS* (ASTERACEAE: ASTEREAE) AND SELECTION OF A NEW LECTOTYPE

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ABSTRACT

Selection of 997.18 (LINN) as the lectotype of *Aster amellus* L. is rejected because the specimen is in conflict with the protologue. A new lectotype is designated from authentic material seen by Linnaeus. Rejecting the original lectotypification and selecting an appropriate specimen circumvents the need for conservation or redefining the concept of the genus *Aster* L. Herb. Linn. 997.16 (LINN) is designated the new lectotype of *Aster amellus*.

RESUMEN

Se rechaza la selección del pliego 997.18 (LINN) como lectotipo de *Aster amellus* L. porque el espécimen está en conflicto con el protólogo. Se designa un nuevo lectotipo a partir de material auténtico visto por Linnaeus. El rechazo de la lectotipificación original y la selección de un espécimen apropiado evita la necesidad de conservación o redefinición del concepto del género *Aster* L. El pliego Herb. Linn. 997.16 (LINN) se designa nuevo lectotipo de *Aster amellus*.

Semple (1998) designated Herb. Linn. 997.18 (LINN) as the lectotype of *Aster amellus* L. (Astereaceae: Astereae). Recently, this lectotypification was found to be flawed and would result in a change in the application of the name *Aster* of which *A. amellus* is the generitype. The simplest solution to this situation is to reject the original lectotypification because the selection was in conflict with the protologue. An alternative solution would be to propose conservation of *A. amellus* with a conserved type, which does not seem necessary in this case.

In choosing 997.18 (LINN) as the lectotype for *Aster amellus* for the Linnaean Typification Project (Semple 1998), I worked from a set of small photographs I had taken in 1984 during visits to the Linnaean Herbarium (LINN) and the British Museum of Natural History (BM) and from additional notes made in 1994 on numerous authentic specimens of asters and goldenrods. Other authentic specimens were rejected as possible types then, and additional specimens and photographs have subsequently come to my attention. 997.18 (LINN) is here rejected as the lectotype for *Aster amellus* on the basis of being in conflict with the protologue. Article 9.17(b) of the ICBN (McNeill et al. 2006) permits the supersession of a lectotype, if it is in serious conflict with the protologue, and another element that is not in conflict is available. At least one specimen that does not conflict with the protologue, Herb. Linn. 997.16 (LINN), is available.

In the protologue of *Aster amellus*, Linnaeus (1753, p.873) indicated the occurrence of some variation in leaf and phyllary traits, and he noted the range as "Habitat in Europae australis asperis collibus," that is, native to rugged hills in southern Europe. Leaves were described as "lanceolatis obtusis scabris trinervis integris" and phyllaries as "calycinis obtusis" in the diagnosis. LINN 997.18 has linear, uninervate rather than lanceolate trinervate leaves and linear acute rather than obtuse phyllaries. The small black and white

photograph of 997.18 (LINN) that I worked from was cropped and lacked critical annotations that are obvious in the colored image of the specimen currently posted on the Linnaean Typification Project web site http://internt.nhm.ac.uk/jdsml/research-curation/projects/linnaean-typification/index.dsml. Upon seeing this image, I knew immediately that I had made a mistake in my choice of lectotype for *Aster amellus*. The specimen was annotated "non A. Amellus" by James Edward Smith (Charlie Jarvis, pers. comm.), who bought Linnaeus' herbarium and moved it to England, and as "Calimeris A.G" by Asa Gray. Clearly, these annotations are critical because they indicate the practical consequences of retaining 997.18 (LINN) as the type of *Aster amellus*, the generitype; the modern strict application of the name *Aster* (see Nesom 1994; Semple et al. 2002) would fundamentally have to be changed. 997.18 (LINN) is likely a member the *Galatella* Cass. / *Crinitaria* Cass. complex rather than *Aster*.

The second paragraph of the protologue deals with the first synonym Linnaeus cited from Hortus Cliffortianus. The voucher of the synonym cited as "Hort. Cliff. 407." is Clifford Herb. No. 407 (BM!) and was diagnosed by Linnaeus as having leaves "lanceolatis scabris semiamplexicaulisbus serratus" and phyllaries as "lanceolatis." Linnaeus noted that the "Hort. Cliff." reference was previously cited in "Royen" and "Gmelin." Clifford Herb. No. 407 (BM) is a possible choice for lectotype for *Aster amellus*. The specimen is a fragment, and in leaf features it is similar to Herb. Linn. 997.17 (LINN), a specimen of *A. pyrenaeus* Desf. ex DC. in Lam. & DC. The Clifford herbarium specimen is rejected as a choice for the new lectotype of *A. amellus*.

Retypification

Herb. Linn. 997.16 (LINN) is also an authentic specimen and is annotated "5 Amellus" likely by Linnaeus himself (Charlie Jarvis, pers. comm.). I have no data indicating I saw this specimen in 1984 or 1994. A photograph of this specimen was given to me after 1998 by Paul Van Faasen, who took the picture. The plant illustrated is very similar to plants in my research collection of *Aster amellus* collected for me in Switzerland by Dr. Erich Weber. 997.16 (LINN) and the Weber collections match the description of *Aster amellus* in the diagnosis of the protologue in both leaf and phyllary traits. These correspond well with the description and figures of *A. amellus* in Wagenitz (1979) and the description of the species in Merxmüller, Schreiber and Yeo (1976). Therefore, Herb. Linn. 997.16 (LINN) is here designated the new lectotype of *Aster amellus*.

Aster amellus L., Sp. Pl. 2:873. 1753. TYPE: EUROPE: habitat in Europae australis asperis collibus, [native to rugged hills in southern Europe], Herb. Linn. 997.16 (LECTOTYPE here designated as new: LINN).

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S. Inderjit (ed.). 2005. **Invasive Plants: Ecological and Agricultural Aspects.** (ISBN 3-7643-7137-4; 978-3-7643-7137-1, hbk.). Birkhauser Verlag, P.O. Box 133, CH-4010 Basel, SWITZERLAND. (**Orders:** Springer, 333 Meadowlands Parkway, Secaucus, NJ 07094, U.S.A.; 800-SPRINGER; fax 201-348-4505; www.springer.com). $159.00, 283 pp., illustrations, 6 1/2" × 9 1/4".

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TRICHOME MORPHOLOGY IN SELECTED MEXICAN RED OAK SPECIES (*QUERCUS* SECTION *LOBATAE*)

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ABSTRACT

Mature leaves and twigs from thirty red oak species, mostly endemic to Mexico, were examined with SEM to assess trichome morphology. Ten trichome types were identified: two glandular and eight nonglandular. Described for the first time in the oak literature are fasciculate contorted, fasciculate crested, and multiple stellate trichomes. Furthermore, three trichome types are reported for the first time in red oaks: stellate, fused stellate, and glandular branched. The most common types on the twigs examined are fasciculate sessile and multiradiate trichome while the most frequent types on the abaxial leaf surfaces are fasciculate sessile, fasciculate stipitate, and multiradiate trichomes. In contrast to the significant morphological variation found in oak leaf shape, trichome complements within each species are nearly invariable and therefore useful in the identification of most species. In summary, together with vegetative and reproductive characters, trichome morphology provides additional information for the identification and characterization of Mexican oak species.

RESUMEN

Hojas maduras y ramillas de treinta especies de encinos rojos, principalmente endémicos a Mexico, fueron examinadas con microscopía electrónica de barrido para evaluar la variación morfológica de tricomas. En este trabajo se identificaron diez tipos de tricomas: dos glandulares y ocho no glandulares. De estos, se describen por primera vez para encinos los tricomas fasciculado contorto, fasciculado crestado y estrellado multiple. Además, se reportan por primera vez para encinos rojos tres tipos de trichomes: estrellado, estrellado fusionado y glandular ramificado. Los tipos de trichoma más comunes en ramillas son el fasciculado sésil y el multiradiado, mientras que en el envés de las hojas los tipos de tricoma más frecuentes son el fasciculado sésil, fasciculado estipitado y el multiradiado. Aunque los encinos muestran una gran variación en morfología foliar, los tipos de tricomas presentes en cada especie son constantes y por lo tanto son muy útiles en la identificación de la mayoría de las especies. En resumen, los caracteres vegetativos y reproductivos junto con la morfología de trichomes proporcionan información valiosa para la identificación y caracterización de las especies Mexicanas de encino.

INTRODUCTION

The genus *Quercus* (Fagaceae) consists of approximately 400 species of trees and shrubs distributed in temperate and subtropical regions of the Northern Hemisphere. In the Americas, *Quercus* is found from southern Canada to Colombia with representatives of three sections within the subgenus *Quercus*: *Quercus* (white oaks), *Protobalanus* (intermediate oaks), and *Lobatae* (red oaks) (Nixon 1993). Due to the large diversity of white and red oaks, Mexico is considered the center of diversity for the genus in the New World (Rzedowski 1965; Nixon 1993).

The number of red oak species has been estimated around 195 (Jensen 1997) with about 55 species endemic to Mexico (Nixon 1993). In his treatment on the American oaks, Trelease (1924) segregated the red oak species into 73 series and also proposed a classification based on leaf and fruit morphology. However, his hypothesis on the relationships of red oak species has not been tested with phylogenetic methods. Although the mono-

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phyly of the red oak section is well supported (Nixon 1984; Manos 1999), an intrasectional phylogeny for the red oaks is yet to be conducted. As in other oak groups, Mexican oak species are difficult to study because most of them show significant amounts of foliar polymorphism. Species identity becomes even more complex when either hybridization or introgression has taken place. Therefore, taxonomic problems in many oak species persist, particularly in those species that have similar or overlapping leaf morphology.

The utility of trichome morphology for species identification has been demonstrated in several plant families such as Brassicaceae, Geraniaceae, and Sterculiaceae (Inamdar & Rao 1983; Metcalfe & Chalk 1950; Oosthuizen 1983; Shanmuka Rao 1987). In oaks, trichome characterization has been carried out for several eastern North American, Asian, and European species. The first study on trichome morphology of eastern North American oak species was reported by Dyal in 1936, who classified them, based on secretory function, into glandular and nonglandular. Camus (1934–1953) described seven trichome types that fall into the glandular and nonglandular categories previously described by Dyal (1936). Hardin (1976) published the first comprehensive work on oak trichome morphology for 58 eastern United States (US) oak species and recognized 10 trichome types. Thomson and Mohlenbrock (1979), Jones (1986), and Manos (1993b) conducted similar studies on other U.S. oak species. Trichome morphology of European and Mediterranean oak species has also been extensively documented by several authors (Olsson 1976; Kissling 1977, 1993; Safou & Saint-Martin 1989; Gellini et al. 1992; Llamas et al. 1995; Bussotti & Grossoni 1997). Trichome morphology, together with other vegetative and reproductive characters, has been used to discriminate several U.S. oak species, as well as a few Mexican species distributed in the northwest of the country (Tucker 1952; Tucker & Muller 1957; Nixon & Steele 1981; Spellenberg 1992, 1998; Nixon & Muller 1993; Bacon & Spellenberg 1996). However, to date, no in-depth research on the trichome morphology of Mexican taxa has been carried out. Several regional taxonomic treatments of Mexican oak species have been conducted (González 1986; Valencia 1989; Vázquez 1992, 2000; Spellenberg et al. 1998; Spellenberg 2001), but none of them has characterized trichome diversity. Only a few authors have discussed the potential utility of trichome types for identification of Mexican species (McVaugh 1974; Rzedowski & Rzedowski 1979; Vázquez 1992). Accordingly, the objective of this study is to characterize the trichome morphology from twigs and leaves from thirty Mexican red oaks, mainly endemic to Mexico, using scanning electron microscopy (SEM). Detailed examination of these species revealed the presence of ten trichome types: four of these trichomes have been previously described, three of them represent entirely new trichome types, and the remaining three are trichome types not previously documented for red oaks. Each species examined shows a particular trichome complement which, together with other vegetative and reproductive characters, provides useful information for species identification and characterization.

MATERIALS AND METHODS

Leaves and twigs from thirty species of red oak species chiefly endemic to Mexico were selected for examination of trichome morphology under SEM. Nixon (1993) has reported 41 red oak species endemic to Mexico, of which, twenty-one have persistent indument and were sampled in this study. Two additional species with persistent indument (*Q. castanea* and *Q crassifolia)* whose range extends to Central America were included in this study because they are widely distributed in Mexico. For comparison, six glabrous

TABLE 1. Red oak species (*Quercus*) examined with SEM for trichome morphological variation. Voucher specimens are deposited at Bailey Hortorium, Cornell University (BH).

Taxa	Voucher specimen
Q. acherdophylla Trelease	*Vázquez et al. 3065*
Q. affinis Scheidweiler	*Muller 9716*
Q. aristata Hooker & Arnott	*Martínez 31, Breedlove 1640*
Q. candicans Née	*Vázquez et al. 3095*
Q. castanea Née	*Rzedowski 25361*
Q. coahuilensis Nixon & Muller	*Stewart 924*
Q. coccolobifolia Trelease	*Vázquez & Phillips 3084*
Q. conzattii Trelease	*Muller 9420*
Q. crassifolia Humboldt & Bonpland	*Vázquez et al. 3049*
Q. crassipes Humboldt & Bonpland	*Vázquez et al. 3037, 3070*
Q. depressa Humboldt & Bonpland	*Vázquez & Tenorio 118*
Q. durifolia von Seemen	*Muller 3579*
Q. x *dysophylla* Bentham	*Nixon s.n. (Oct. 1999)*
Q. eduardii Trelease	*Nixon 4034, Vázquez et al. 3011*
Q. fulva Liebmann	*Vázquez et al. 3097*
Q. gentryi Muller	*McVaugh 25635*
Q. hintonii Warburg	*Vázquez et al. 3029*
Q. hintoniorum Nixon & Muller	*Eckelman 21, Poole 2336*
Q. hirtifolia Vázquez, Valencia & Nixon	*Vázquez et al. 3069, 3109*
Q. hypoleucoides Camus	*Yen & Estrada 8338*
Q. hypoxantha Trelease	*Cowan et al. 5402*
Q. mcvaughii Spellenberg	*Bacon et al. 5284*
Q. mexicana Humboldt & Bonpland	*Rzedowski 6374*
Q. planipocula Trelease	*McVaugh12136*
Q. radiata Trelease	*Rzedowski 23018*
Q. salicifolia Née	*McVaugh 25456*
Q. scytophylla Liebmann	*Vázquez et al. 3035*
Q. sideroxyla Humboldt & Bonpland	*Vázquez et al. 3089, Bacon et al. 5304*
Q. tarahumara Spellenberg, Bacon & Breedlove	*Bacon et al. 5307, 5375*
Q. urbanii Trelease	*Vázquez et al. 3027*

red oak species endemic to Mexico were included. Samples of the materialexamined were gathered from field collections and from herbarium specimens deposited at the Bailey Hortorium, Cornell University (BH) (Table 1).

Twenty to thirty specimens per species were initially examined under dissecting and light microscopy to survey the intra- and interspecific variation in trichome morphology. A more detailed examination was carried out under SEM in representative subsamples. About one square cm of the abaxial surface of a dry leaf or one cm of twig was mounted on an aluminum stub with no prior treatment. Previous studies have shown no difference in the preservation of nonglandular trichome structure using either fresh or dry tissue (Hardin 1976). Specimens mounted on stubs were sputter coated with 30 nm of gold palladium using a BAL-TEC sputter coater. Samples were observed under a Zeiss electron microscope, model LEO DSM 960, using working distances between 12 and 18 mm, voltages of 3.0 or 4.0 kV, and apertures of 300 µm or 400 µm depending on the sample and magnification. Most trichome micrographs were taken at magnifications of 200×, although smaller trichomes required magnifications of 450–500×.

TABLE 2. Trichome types on twigs of Mexican red oak species (*Quercus*).

Species	Glandular		Nonglandular			
	Simple uniseriate	Branched	Fasciculate sessile simple	Fasciculate stipitate	Multiradiate	Simple Stellate
Q. acherdophylla	X					X
Q. affinis					X	
Q. aristata				X		
Q. candicans			X		X	X
Q. castanea			X			
Q. coahuilensis			X	X		
Q. coccolobifolia	X		X			
Q. conzattii			X		X	
Q. crassifolia	X		X	X		
Q. crassipes			X		X	
Q. depressa					X	
Q. durifolia			X		X	
Q. × dysophylla			X	X		
Q. eduardii			X		X	
Q. fulva			X		X	
Q. gentryii					X	
Q. hintonii			X		X	
Q. hintoniorum			X		X	
Q. hirtifolia			X	X		
Q. hypoleucoides			X		X	
Q. hypoxantha			X		X	
Q. mcvaughii			X		X	
Q. mexicana			X		X	
Q. planipocula			X			
Q. radiata			X			
Q. salicifolia	X					
Q. scytophylla			X		X	
Q. sideroxyla			X		X	
Q. tarahumara			X			
Q. urbanii			X		X	

RESULTS

Trichome nomenclature follows Hardin (1976), where each cell composing a nonglandular trichome is called a "ray" and trichome types are named based on the degree of ray fusion, ray orientation, and overall morphology. However, additional terms have been introduced to describe trichome types not previously reported in the literature.

Two general trichome categories are used to indicate secretory functions and nature of the cell wall: 1) glandular trichomes have a glistening appearance and thin cell walls that collapse upon drying, and 2) nonglandular trichomes lack a glistening appearance and possess thick cell walls. Examination of twigs and abaxial leaf surfaces of thirty red oak species resulted in two types of glandular trichomes and eight nonglandular trichome types (Tables 2 and 3).

Glandular trichomes

1. *Simple uniseriate (Fig. 1A, 1B).*—This type consists of 2–7 united cells with slight constrictions along the trichome length. This trichome type was commonly found on

TABLE 3. Trichome types in oak species (*Quercus*) with a persistent indumentum on the abaxial leaf surfaces.

Species	Glandular		Nonglandular							
	Simple uniseriate	Branched	Fasciculate sessile simple	Fasciculate sessile contorted	Fasciculate sessile crested	Fasciculate stipitate	Multi-radiate	Simple stellate	Fused stellate	Multiple stellate
Q. acherdophylla						Xv				
Q. affinis						Xv				
Q. aristata			X			X				
Q. candicans	X						X	X	X	
Q. castanea	X		X							
Q. coahuilensis	X		X							
Q. coccolobifolia	X					Xv				
Q. conzattii						X				
Q. crassifolia	X		X			X				
Q. crassipes	X					X				
Q. depressa						Xv				
Q. durifolia							X	X		
Q. × dysophylla	X					X				
Q. eduardii				X						
Q. fulva	X						X			
Q. gentryi	X							X		Xs
Q. hintonii	X		X			X				
Q. hintoniorum	X					Xv	X			
Q. hirtifolia			X			X				
Q. hypoleucoides	X						X			
Q. hypoxantha	X		X							
Q. mcvaughii	X		X							
Q. mexicana	X			X						
Q. planipocula	X					X				
Q. radiata	X		X							
Q. salicifolia		Xs					Xs			
Q. scytophylla	X						X			
Q. sideroxyla	X				X		X			
Q. tarahumara	X		X			X				
Q. urbanii	X					X				

s=scattered

v=trichomes on secondary veins

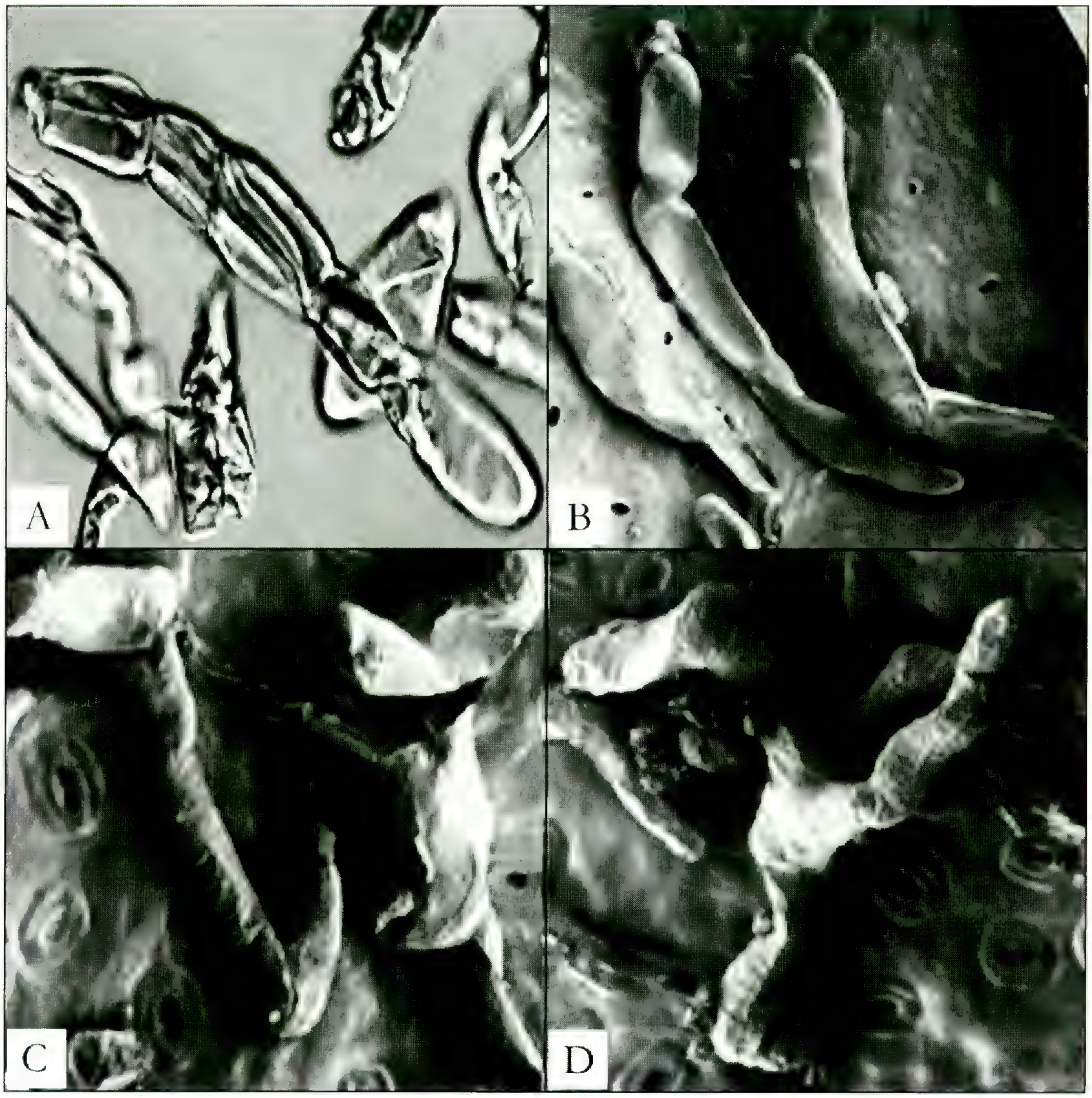


FIG. 1. **A.** Thin cell wall in a glandular trichome of *Quercus coccolobifolia*. ×40. **B.** Glandular simple uniseriate trichome on the abaxial leaf surface of *Q. hintoniorum*, ×500. **C.** Glandular branched trichome on the abaxial surface of *Q. salicifolia*, ×500. **D.** A variation of the glandular branched trichome on the abaxial leaf surface of *Q. salicifolia*, ×500.

the abaxial leaf surfaces of twenty-one species, forming a sparse and deciduous indumentum. In most species examined, trichome density decreased during leaf maturation and senescence; however, *Quercus coccolobifolia* showed persistent simple uniseriate trichomes on the abaxial leaf surface. This trichome type was found on the twigs of only three species: *Q. acherdophylla*, *Q. coccolobifolia*, and *Q. crassifolia* (Table 2).

2. *Branched (Fig. 1C, 1D).*—This type consists of 2–3 cells united in either a V or a Y shape; however, under the dissecting microscope this trichome type looks like two unicellular simple trichomes lying next to each other. This trichome type was found exclusively on abaxial surfaces of *Q. salicifolia* leaves.

Nonglandular trichomes

Fasciculate sessile trichomes.—These consist of several rays fused at the point of attachment to the epidermis. The rays are either short and completely erect (Fig. 2A), or long

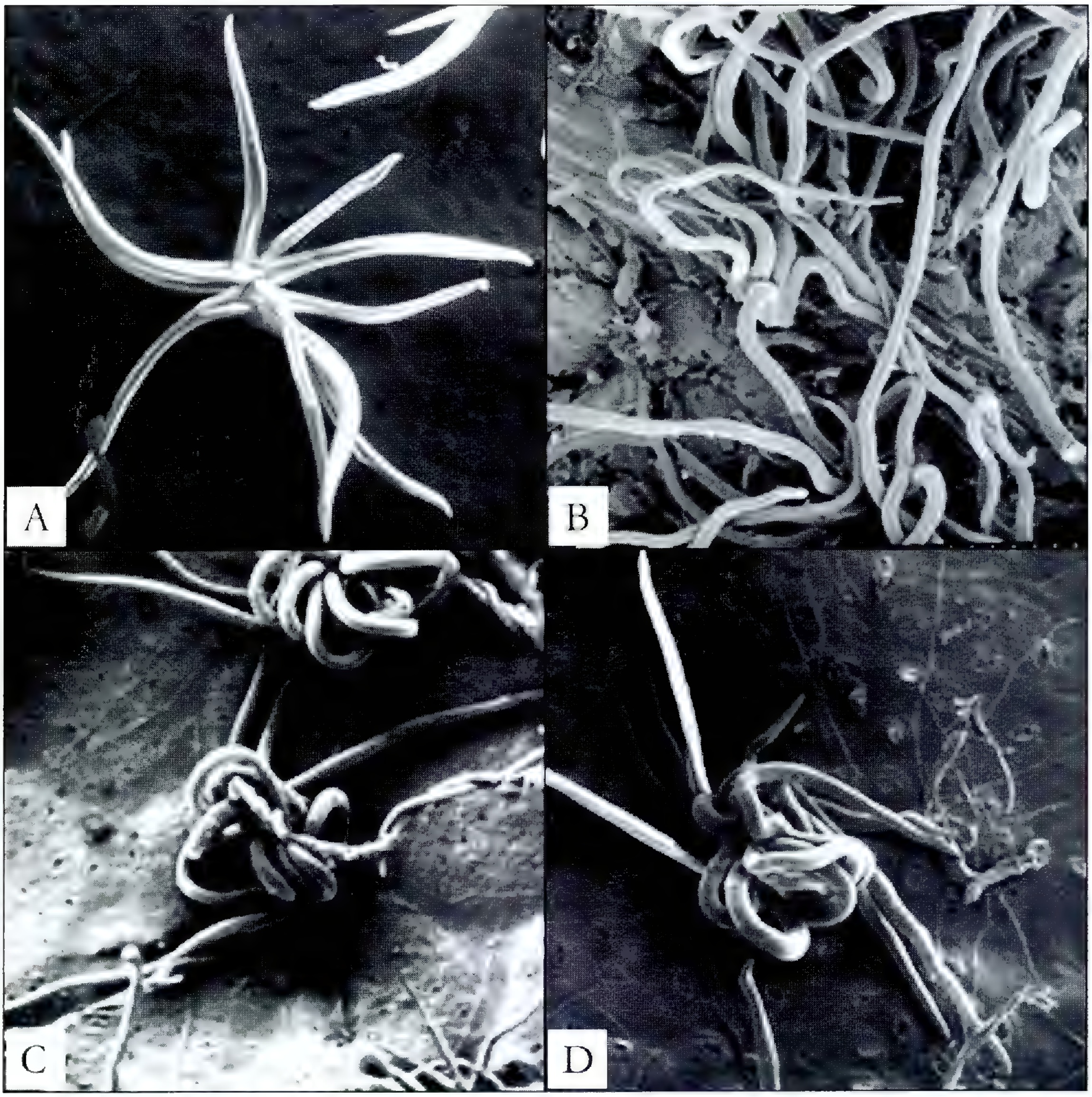


FIG. 2. **A.** Fasciculate sessile simple trichome on the abaxial leaf surface of *Quercus aristata,* ×200. **B.** Fasciculate sessile simple trichome on the abaxial leaf surface of *Q. crassifolia,* ×200. **C.** Fasciculate sessile contorted trichome on the abaxial leaf surface of *Q. mexicana,* ×200. **D.** Fasciculate sessile contorted trichome on the abaxial leaf surface of *Q. eduardii* ×200.

and tortuous diverging in different directions (Fig. 2B). Three types of fasciculate sessile trichomes are recognized in the species examined.

1. *Fasciculate sessile simple (Fig. 2A, 2B).*—The fasciculate sessile trichome described by Hardin (1976; 1979a) and Jones (1986) is termed here fasciculate sessile simple to distinguish it from the two additional subtypes listed below. This trichome type was found on twigs and/or on the abaxial leaf surfaces of several species examined. It occurs on twigs of the following species: *Q. candicans, Q. castanea, Q. coahuilensis, Q. coccolobifolia, Q. conzattii, Q. crassifolia, Q. crassipes, Q. durifolia, Q.* x *dysophylla, Q. eduardii, Q. fulva, Q. hintonii, Q. hintoniorum, Q. hirtifolia, Q. hypoleucoides, Q. hypoxantha, Q. mcvaughii, Q. mexicana, Q. planipocula, Q. radiata, Q. scytophylla, Q. sideroxyla, Q. tarahumara* and *Q. urbanii.* Species bearing this trichome type on abaxial leaf surfaces are *Q. aristata, Q. castanea, Q. coahuilensis, Q. crassifolia, Q. hintonii, Q. hirtifolia, Q. hypoxantha, Q. mcvaughii, Q. radiata,* and *Q. tarahumara* (Table 2).

2. *Fasciculate sessile contorted (Figs. 2C, 2D).*—This study describes this trichome type for the first time. Contorted trichomes are similar to the fasciculate sessile simple trichome described above except that the rays curl down and then twist around the trichome axis. This ray arrangement gives the indumentum a punctate appearance when observed with the naked eye or at low magnification. This trichome type has been found on the abaxial leaf surface of only two species of Mexican red oaks: *Q. mexicana* and *Q. eduardii*.

3. *Fasciculate sessile crested (Fig. 3A).*—This is a new trichome type that consists of rays united along a longitudinal axis oriented parallel to the epidermis. The united rays result in a structure that resembles a crest. Trichomes of this type were found only on the abaxial surface of some *Q. sideroxyla* specimens.

4. *Fasciculate stipitate (Figs. 3B, 3C).*—Morphologically, this trichome type is similar to the fasciculate sessile simple except that the basal parts of the rays fuse, forming a stipe. The degree of ray fusion varies among species from 1/12 to 1/4 the total ray length. Ray length and degree of divergence are also different; some species display short and straight rays (Fig. 3B) while others show long curly rays that become intertwined with adjacent rays (Fig. 3C). Ray number is variable within and among species, although intraspecific ranges are low. Fasciculate stipitate trichomes form a persistent indumentum on the abaxial leaf surface of the following species: *Q. conzattii*, *Q. crassifolia*, *Q. crassipes*, *Q.* x *dysophylla*, *Q. hintonii*, *Q. hirtifolia*, *Q. planipocula*, *Q. tarahumara*, and *Q. urbanii*. In *Q. aristata*, fasciculate stipitate trichomes are deciduous and scattered on the abaxial leaf surface. In many otherwise glabrous species, such as *Q. acherdophylla*, *Q. affinis*, *Q. coccolobifolia*, *Q. depressa*, and *Q. hintoniorum*, only a few fasciculate stipitate trichomes remain attached to the epidermis at the secondary vein axils. Fasciculate stipitate trichomes on twigs were less common and found only in *Q. aristata*, *Q. coahuilensis*, *Q. crassifolia*, *Q.* x *dysophylla* and *Q. hirtifolia*.

5. *Multiradiate (Figs. 3D, 4A, 4B).*—This trichome type is characterized by the divergence of rays in different directions from the central axis. In the species examined, the rays differ not only in length but also in thickness. Multiradiate trichomes were found on both twigs and abaxial leaf surfaces of *Q. candicans*, *Q. durifolia*, *Q. fulva*, *Q. hintoniorum*, *Q. hypoleucoides*, *Q. scytophylla*, and *Q. sideroxyla*. This trichome type was found only on the twigs of the following species: *Q. affinis*, *Q. conzattii*, *Q. crassipes*, *Q. depressa*, *Q. eduardii*, *Q. gentryi*, *Q. hintonii*, *Q. hypoxantha*, *Q. mcvaughii*, *Q. mexicana*, and *Q. urbanii*. Multiradiate trichomes occurring on abaxial leaf surfaces usually form a persistent indument; however, in *Q. salicifolia* these trichomes are found scattered sparsely across the lamina.

6. *Simple stellate (Figs. 4C, 4D, 5A).*—This trichome type consists of rays appressed to the lamina, usually fused at their base, forming a structure that resembles a starfish. Simple stellate trichomes are composed of seven to fifteen rays, which vary in length, thickness, and size. This trichome type was previously described by Hardin (1976) and Jones (1986) under the term stellate. Here the term simple stellate is used to set it apart from the multiple stellate and fused stellate also found in this study. Simple stellate trichomes were found on the twigs of *Q. acherdophylla*, and *Q. candicans*, as well as on the abaxial leaf surfaces of *Q. candicans*, *Q. durifolia* and *Q. gentryi*.

7. *Multiple stellate (Fig. 5B).*—This new trichome type consists of 2–3 stellate trichomes joined together forming a trichome cluster. It was found only on one species, scattered on the abaxial leaf surface of *Q. gentryi*.

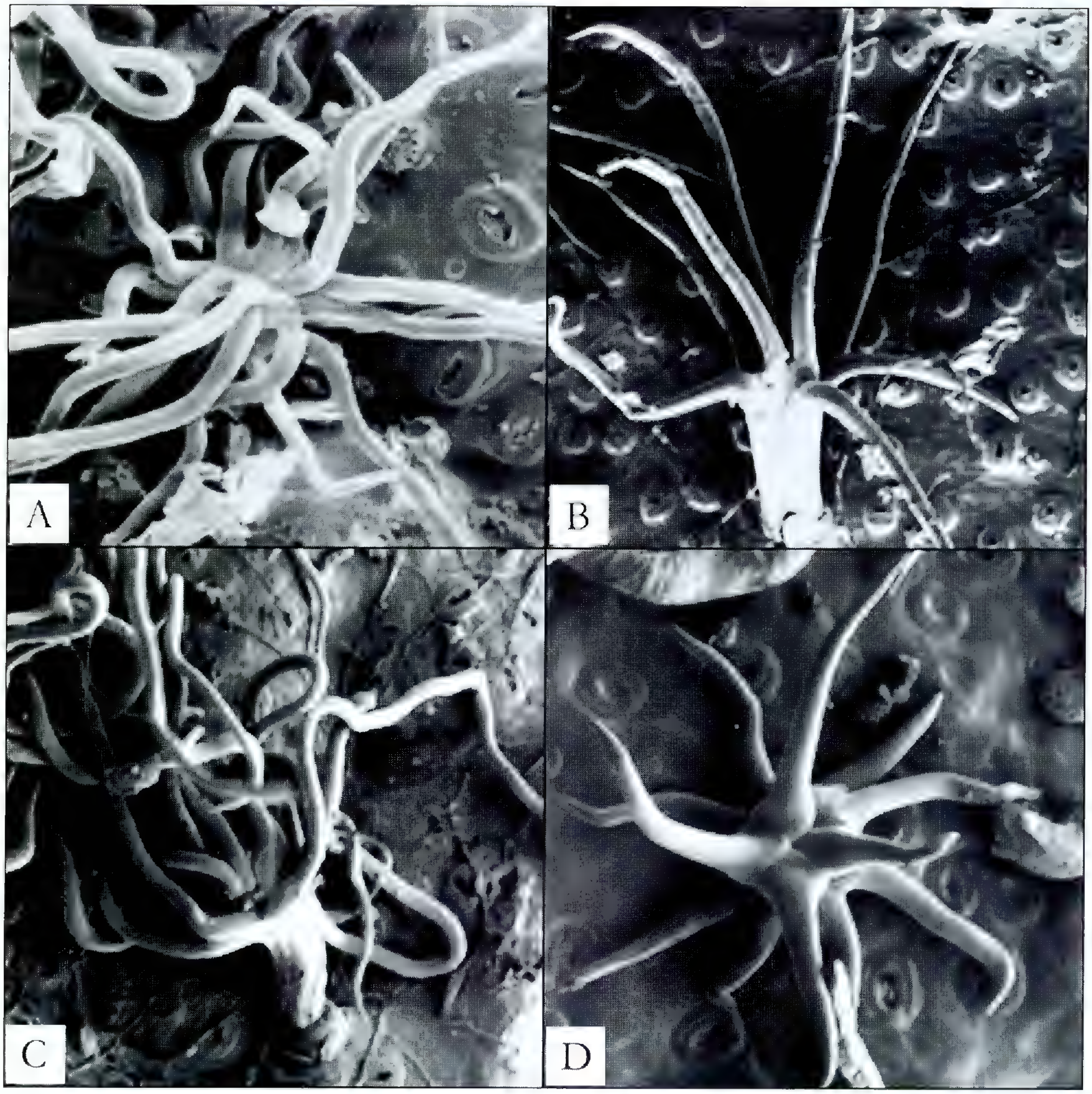


FIG. 3. **A.** Fasciculate sessile crested trichome on the abaxial leaf surface of *Quercus sideroxyla,* ×450. **B.** Fasciculate stipitate trichome on the abaxial leaf surface of *Q. aristata,* ×200. **C.** Fasciculate stipitate trichome on the abaxial leaf surface of *Q. conzatti* ×200. **D.** Multiradiate trichome on the abaxial leaf surface of *Q. salicifolia,* ×500.

8. Fused stellate (Fig. 5C).—This trichome type previously described by Hardin (1979a) and Jones (1986) consists of rays fused about one sixth of the ray length. This trichome type, not previously reported for red oaks, was found exclusively on the abaxial leaf surface of *Q. candicans.*

DISCUSSION

The study of trichomes with SEM revealed significant differences in trichomes that appeared similar when viewed with dissecting microscopy. These differences have allowed a more accurate characterization of trichome types and have also led to the discovery of three new nonglandular trichome types: fasciculate contorted, fasciculate crested, and multiple stellate. Fasciculate contorted trichomes, although recognized as a different type by several authors (McVaugh 1974; González 1986), had been included under the stellate

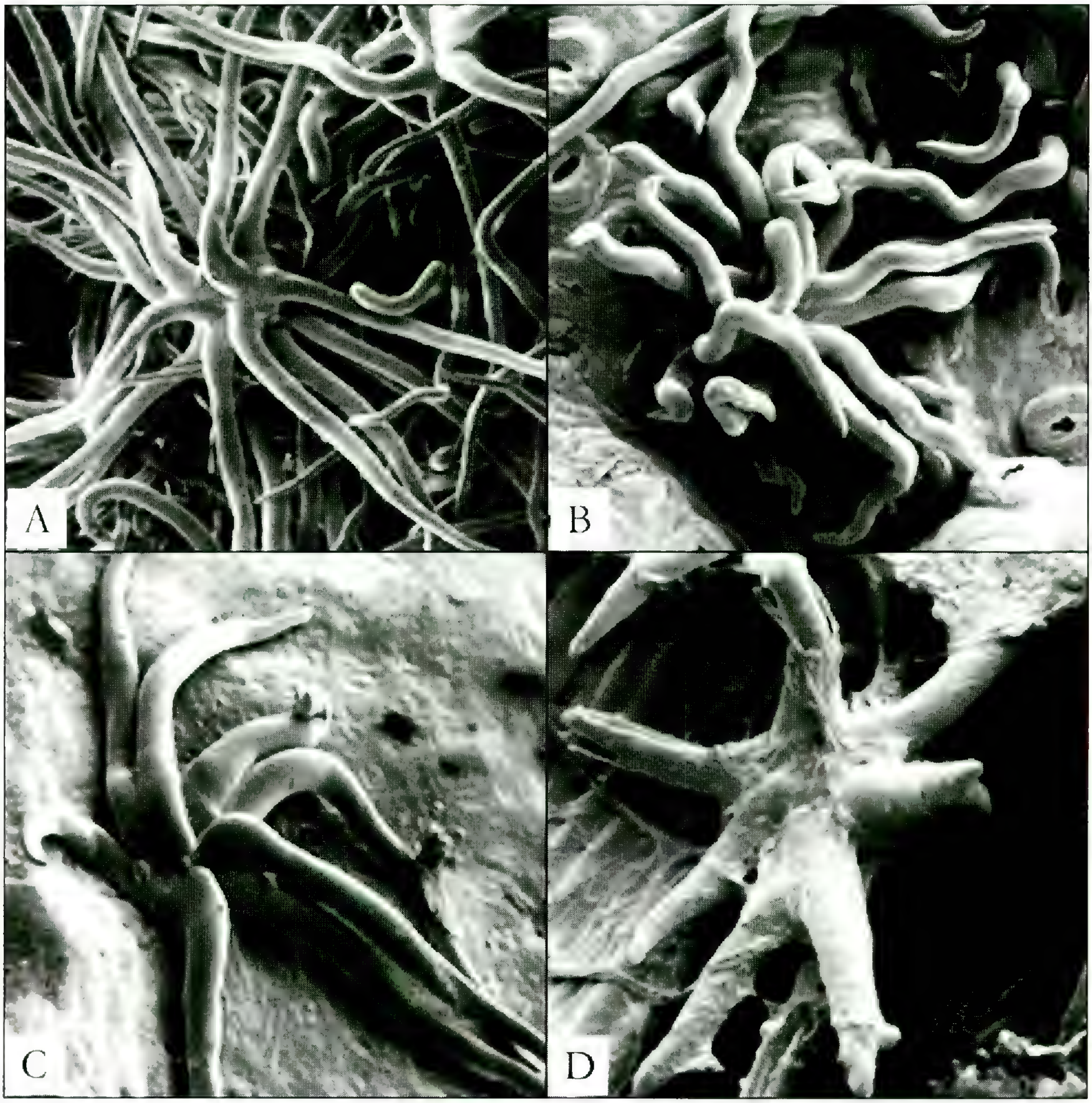


FIG. 4. **A.** Multiradiate trichome on the abaxial surface of *Quercus durifolia,* ×300. **B.** Multiradiate trichome on the abaxial leaf surface of *Q. scytophylla,* ×500. **C.** Simple stellate trichome on the adaxial leaf surface of *Q. eduardii* ×500. **D.** Simple stellate trichomes on the twigs of *Q. acherdophylla* ×800.

type. The second new trichome type, fasciculate simple crested, is found only on the abaxial leaf surface of some *Q. sideroxyla* specimens. The uncommon distribution of fasciculate crested trichomes suggests that they could represent a variation of the multiradiate type, which is an abundant trichome type in the indumentum of *Q. sideroxyla.* The third new trichome type, multiple stellate, is found in a scattered pattern exclusively on the abaxial leaf surface of *Q. gentryi.* Under the dissecting microscope this trichome resembles a multiradiate type but close examination with SEM reveals that it consists of two to three stellate trichomes fused together (Fig. 5B). Therefore, trichomes that appear multiradiate must be examined carefully to avoid inclusion of multiple stellate types into this category. For example, Hardin (1979b) described a trichome type as a dense multiradiate, however, his corresponding illustration (Fig. 30) shows a morphological resemblance to the multiple stellate type described here.

In addition to the new trichome types found in this study, three types represent new

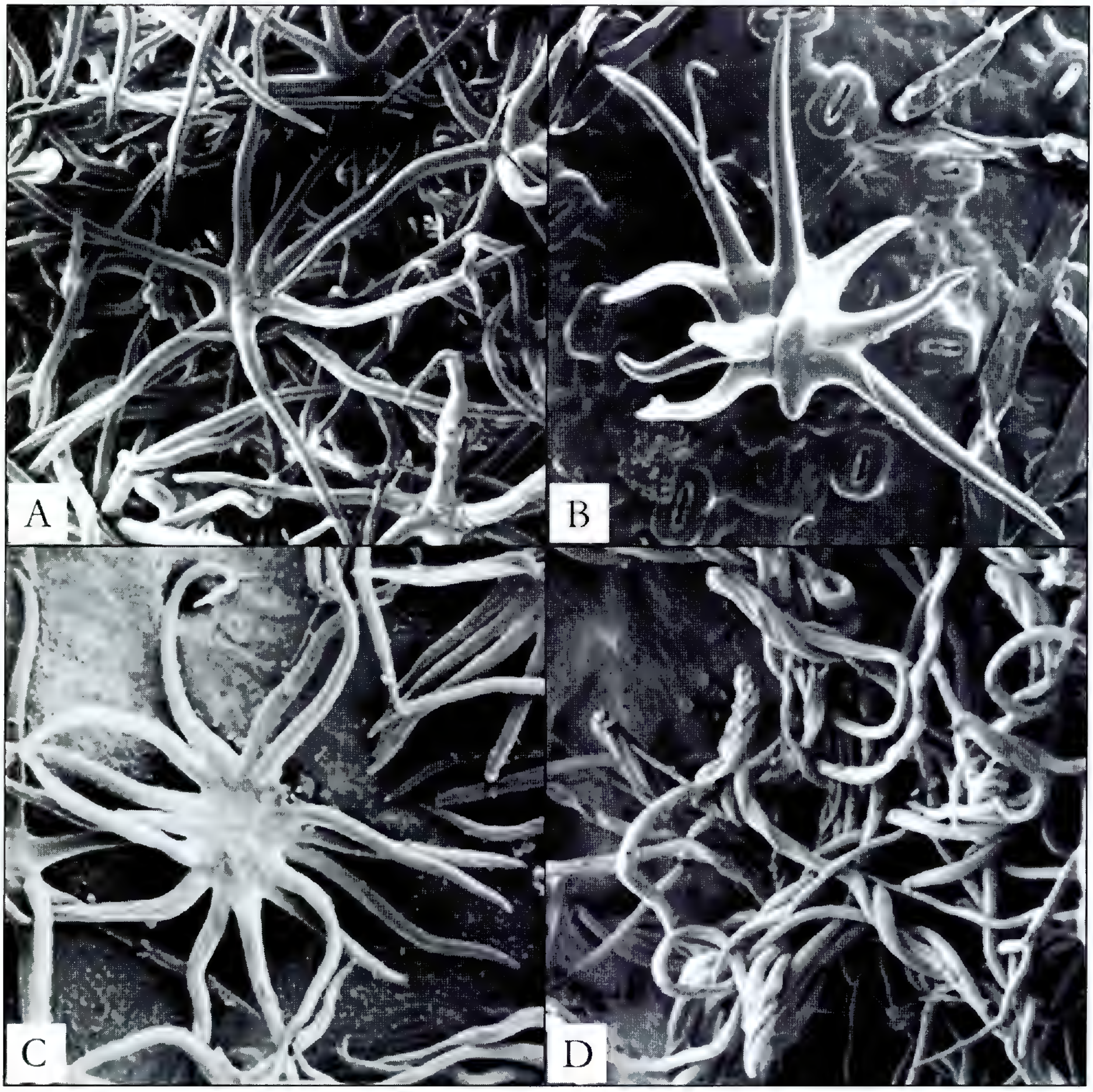


FIG. 5. **A.** Simple stellate trichomes on the abaxial leaf surface of *Quercus durifolia* ×250. **B.** Multiple stellate trichomes on lower leaf surface of *Q. gentryii* _450. **C.** Fused stellate trichomes on the abaxial leaf side of *Q. candicans*, ×200. **D.** Fasciculate sessile trichomes with twisted rays on the abaxial leaf side of *Q. coahuilensis*, ×150.

reports for red oaks: stellate, fused stellate, and glandular branched. Previous research had indicated that stellate and fused stellate types occurred only in white oaks (Hardin 1979a); however, this study found these trichome types in *Q. candicans*. Jones (1986) stated that stellate trichomes are "usually restricted to large veins or sometimes only the petiole." In this research, stellate trichomes were found forming a dense and persistent indumentum on the abaxial leaf surfaces of the aforementioned species. The glandular branched type was rare and only found on the abaxial leaf surface of *Q. salicifolia*. This result supports Hardin's statement (1976) that this trichome type is not very common in red and white oaks.

SEM was also useful in the accurate identification of previously known trichome types. For example, at low magnifications, trichomes on the abaxial leaf surface of *Q. coahuilensis* appear fasciculate stipitate, but examination under SEM has revealed that they are fasciculate sessile: the stipe-like structure is formed by the twisting of rays near

the trichome base (Fig. 5D). Similarly, detailed study of the trichome type denoted as "starred" in several descriptions of Mexican oak species (Bello & Labat 1987; Valencia 1989; Vázquez 1992, 2000; Romero 1993) showed that these categories correspond to four different trichome types: fasciculate sessile, fasciculate stipitate, fasciculate contorted, or multiradiate trichomes. Acknowledging the trichome variation included under the term "starred" will facilitate future characterization of Mexican oak taxa.

Study of twigs under SEM has also revealed remarkable characteristics regarding the nature of the indumentum. Several taxonomic treatments of Mexican oak taxa (González 1986; Valencia 1989; Vázquez 1992) imply that the twig indumentum consists of only one nonglandular trichome type. However, the results of this study indicate that the indumentum of nineteen of the species examined is composed of two to three trichome types arranged in overlapping layers (Fig. 6A). Of the thirty species examined, only nine have a twig indumentum composed of one nonglandular trichome type (Figs. 6B, 6C).

In general, species bearing more than one nonglandular trichome type on twigs and/or leaves show several combinations of glandular and nonglandular trichomes, termed trichome complements. Glandular trichome types are not included in the trichome complements because, if present, they usually are deciduous.

Trichome complements on twigs

The most common trichome complement on twigs is multiradiate/fasciculate sessile simple and occurs in the following species: *Q. conzattii*, *Q. crassipes*, *Q. durifolia*, *Q. eduardii*, *Q. fulva*, *Q. hintonii*, *Q. hintoniorum*, *Q. hypoleucoides*, *Q. hypoxantha*, *Q. mcvaughii*, *Q. mexicana*, *Q. scytophylla*, *Q. sideroxyla*, and *Q. urbanii*. Twigs with a trichome complement consisting of fasciculate sessile simple/fasciculate stipitate trichomes are found in *Q. coahuilensis*, *Q. crassifolia*, *Q.* × *dysophylla*, and *Q. hirtifolia*. A species-specific trichome complement was found on twigs of *Q. candicans* (fasciculate sessile simple/multiradiate/simple stellate) (Table 2).

Trichome complements on the abaxial surface of leaves

The distribution of glandular trichomes on leaves showed different patterns. On one hand, the simple branched glandular trichome type is found exclusively on the abaxial leaf surface of *Q. salicifolia* in a scattered fashion (Fig. 6D). On the other hand, the simple uniseriate type is found on the abaxial leaf surface of most of the species examined. Generally, this trichome is deciduous and usually not found on mature leaves; however, in *Q. radiata* and *Q. coccolobifolia*, these glandular trichomes are persistent in the form of mucilaginous droplets, which according to Uphof (1962) are the result of decaying glandular trichomes. The common presence of simple uniseriate glandular trichomes has also been documented for many US and European oak species (Hardin 1976, 1979a; Llamas et al. 1995), and has also been found in the red oak species examined here.

Trichome complements on the abaxial leaf surface are composed of two to four trichome types (Table 3). The trichome complement fasciculate sessile simple/fasciculate stipitate is found in the species *Q. aristata*, *Q. crassifolia*, *Q. hintonii*, *Q. hirtifolia*, and *Q. tarahumara*. Species-specific trichome complements are present on the abaxial leaf surface of *Q. candicans* (multiradiate/simple stellate/fused stellate), *Q. durifolia* (multiradiate/simple stellate), *Q. hintoniorum* (fasciculate stipitate/multiradiate), and *Q. sideroxyla* (fasciculate sessile crested/multiradiate), (Table 3). Although the occurrence of more than one nonglandular trichome type on the abaxial surface has been documented for European

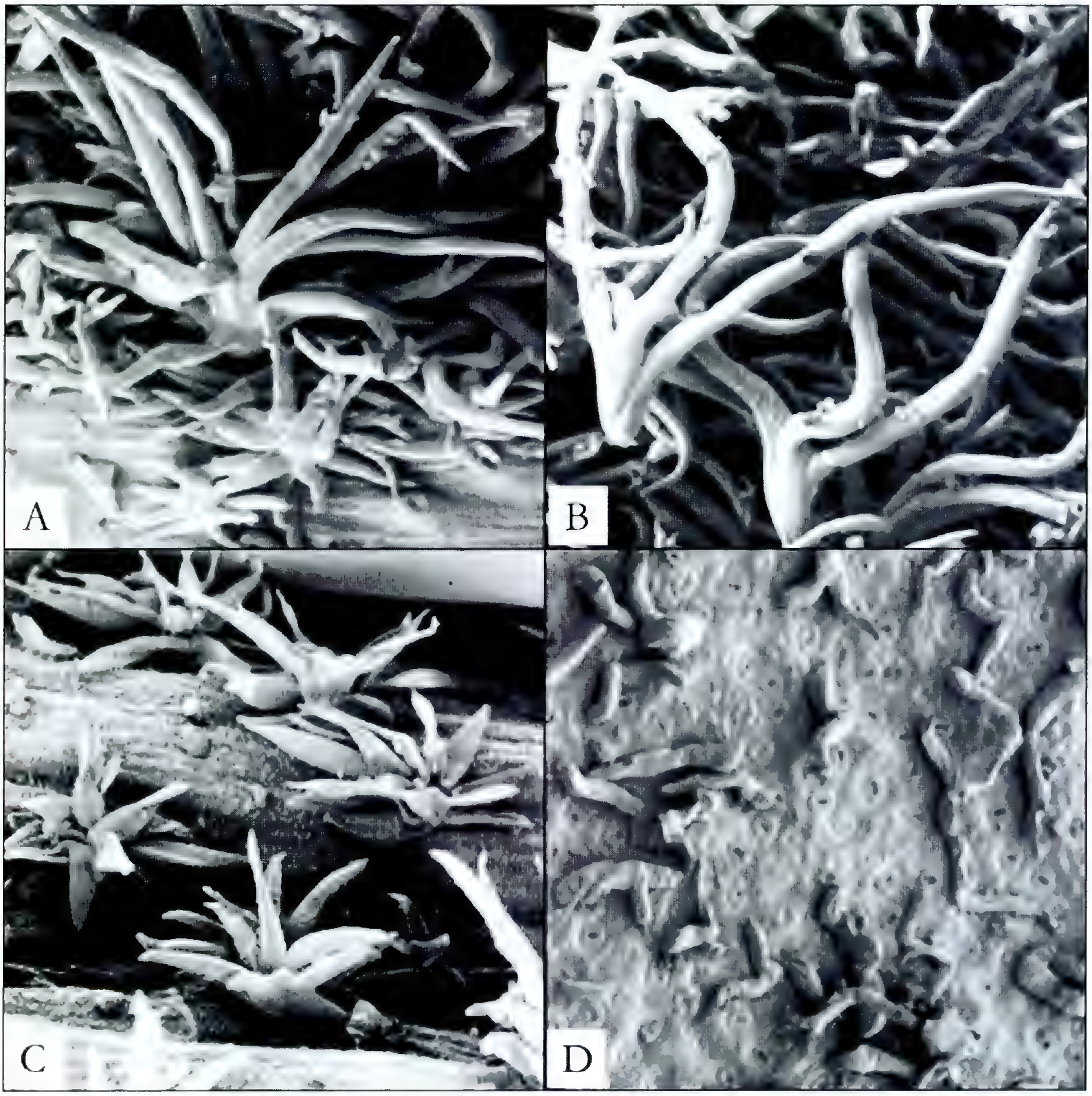


FIG. 6. **A.** Fasciculate and stellate trichomes on the twig of *Quercus candicans,* ×200. **B.** Fasciculate sessile simple (left) or shortly stipitate (right) trichomes on twigs of *Q. hintonii,* ×200. **C.** Multiradiate trichomes on the twigs of *Q. affinis* ×200. **D.** Scattered branched glandular trichomes on the abaxial leaf surface of *Q. salicifolia,* ×200.

(Safou & Saint-Martin 1989) and North American (Thomson & Mohlenbrock 1979) oak species, it has only been described for a few Mexican taxa. For example, Nixon and Muller (1993) described the unique trichome complement found in *Q. hintoniorum* and related species.

The abaxial leaf surface of six of the included species is essentially glabrous except for clusters of fasciculate stipitate trichomes in the vein axils, or scattered multiradiate or stellate trichomes distributed throughout the lamina. Species with fasciculate stipitate trichomes restricted to vein axils are: *Q. acherdophylla, Q. affinis, Q. depressa,* and *Q. coccolobifolia,* although the later species also has abundant simple uniseriate trichomes throughout the abaxial surface. Scattered multiple stellate and multiradiate trichomes have been found only in *Q. gentryi* while dispersed multiradiate and branched glandular trichomes are found in *Q. salicifolia.*

Trichome morphology and species identification

There are several instances where trichome morphology can be a valuable tool in the identification of red oak species, especially of those with similar overall features. For example, *Q. crassipes* and *Q. mexicana* (Figs. 7A, B) are frequently confused because they have similar leaf morphology. However, examination of trichomes on the abaxial leaf surfaces reveals clear differences: while *Q. crassipes* has fasciculate stipitate trichomes, *Q. mexicana* shows fasciculate sessile contorted trichomes. Reproductive characters (e.g. fruit morphology) agree with their distinctiveness based on trichome morphology. Another example of the utility of trichome morphology for species identification is found in the *Crassifoliae* complex (sensu Vázquez 2001), which consists of fourteen species characterized by the presence of a pale-yellow indumentum on the abaxial leaf surface, and by a morphological resemblance to leaves of *Q. crassifolia*. Two species often confused with *Q. crassifolia* are *Q. mcvaughii* and *Q. fulva*. While the abaxial leaf surface of *Q. crassifolia* has distinctive fasciculate stipitate trichomes, *Q. mcvaughii* displays fasciculate sessile trichomes and *Q. fulva* shows multiradiate trichomes on their abaxial leaf surfaces. In fact, trichome differences between *Q. crassifolia* and *Q. mcvaughii*, together with other morphological and reproductive characters were used in the segregation of these morphologically similar species (Spellenberg 1992).

A potential problem in trichome classification is that there are cases when there is not a clear-cut distinction among types. One case involves Hardin's (1976) glandular rosulate trichome type, characterized by the rosette pattern of the rays and, most importantly, the rays having a thin cell wall. In practice, it is difficult to determine the nature of the cell wall unless ultrastructural studies are carried out. In the absence of such studies and taking into account ray arrangement, these trichomes should be classified as multiradiate. In this study, all trichomes with rays originating from a single point and diverging in different directions were considered within the multiradiate type.

A second problem in the identification of trichome types is the transition of one type into another. In the specimens examined, morphological transitions were observed between fasciculate sessile and fasciculate stipitate trichomes, and from fasciculate sessile to stellate. These examples agree with Jones' (1986) statement that sometimes there are no discrete boundaries between trichome types and that "...most forms intergrade with at least one other type ..."

Despite these potential limitations, SEM has been a key factor in the discovery of three new trichome types, as well as in the finding of three trichome types not previously reported for red oaks. Furthermore, study of trichomes under SEM has revealed key morphological differences in apparently similar trichome types. Detailed examination of trichomes from Mexican oak taxa revealed that four different trichome types had been included under the "starred" category in the taxonomic literature. The trichome complements of mature leaves are useful in the identification of morphologically similar oak species when taken together with other vegetative and reproductive features, as indicated in the dichotomous key below. This work provides a standard terminology that could be used in future taxonomic treatments to aid in species circumscription of Mexican oak taxa.

DICHOTOMOUS KEY FOR IDENTIFICATION OF MEXICAN RED OAK SPECIES

1. Abaxial leaf surface either completely devoid of trichomes or appearing glabrous except for scattered glandular or nonglandular trichomes.
   2. Leaf shape ovate to suborbicular or pandurate; abaxial leaf surface with abundant simple

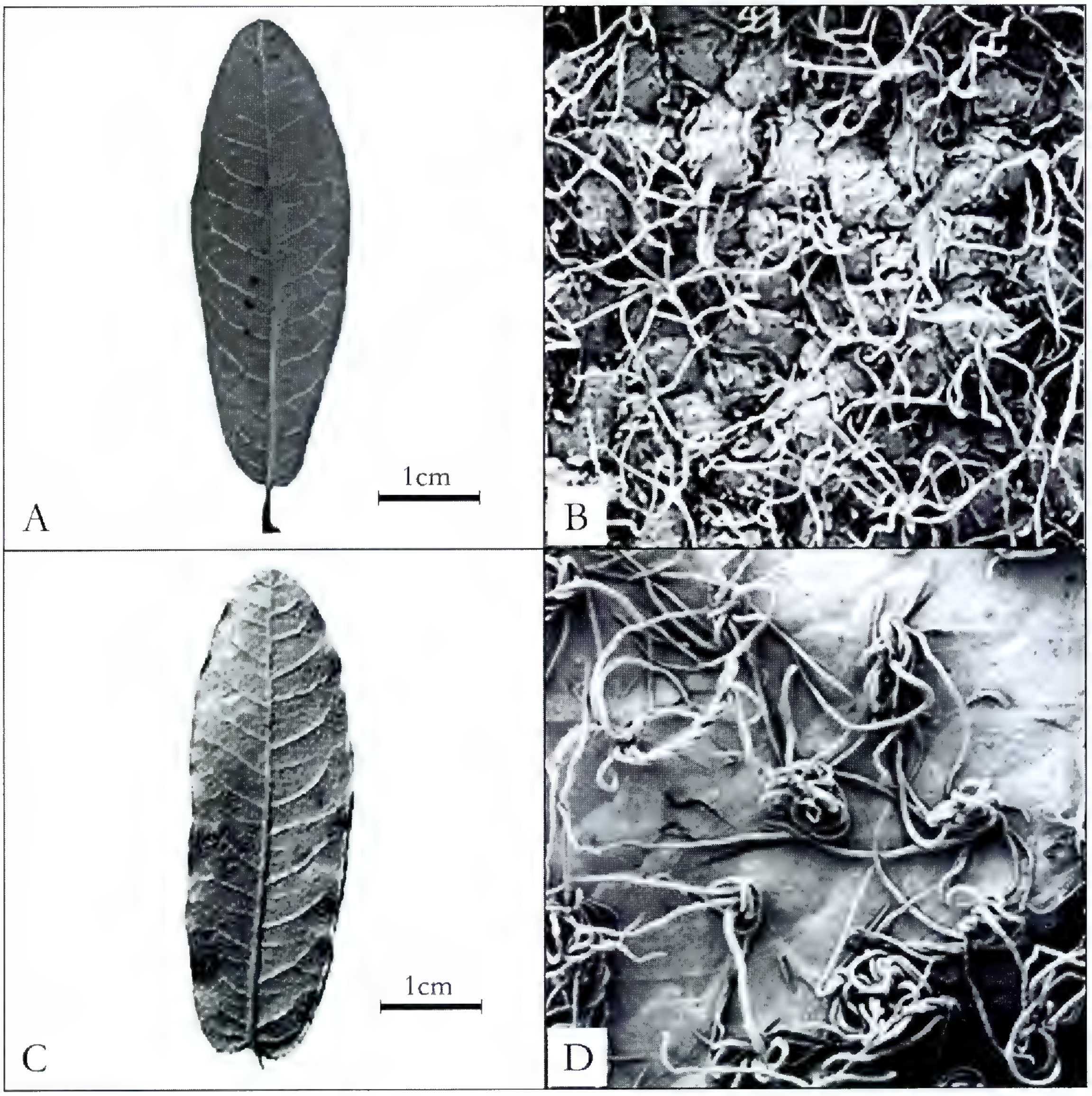


FIG. 7. **A.–B.** *Quercus crassipes,* left, mature leaves; right, fasciculate stipitate trichome on the abaxial leaf surface, ×74. **C.–D.** *Q. mexicana* left, mature leaves; right, fasciculate sessile contorted trichomes on the abaxial leaf surface ×74.

uniseriate glandular trichomes and a few fasciculate stipitate trichomes restricted to the secondary vein axils _____ **Q. coccolobifolia**

2. Leaf shape elliptic, lanceolate, ovate-lanceolate, or oblanceolate; abaxial leaf surface devoid of trichomes or with scattered stellate or multiradiate trichomes.
   3. Leaf margin entire and undulate.
      4. Leaves 4–6 times long as wide; abaxial leaf surface with sparse multiple stellate trichomes or multiradiate trichomes distributed throughout the lamina and vein axils; fruits with biennial maturation.
         5. Secondary veins 10–15; two-thirds of the acorn included in the cup; epidermis on the abaxial leaf surface bullate _____ **Q. gentryi**
         5. Secondary veins 15–25; one-third of the acorn included in the cup; epidermis on the abaxial leaf surface smooth _____ **Q. salicifolia**
      4. Leaves 2–2.5 times long as wide, abaxial leaf surface lacking trichomes on the lamina but with fasciculate stipitate trichomes on the vein axils; fruits with annual maturation _____ **Q. acherdophylla**

3. Leaf margin entire and straight or with short teeth.
   6. Leaf base attenuate, cuneate or decurrent; mature leaves 3.6 ·4.2 times long as wide _____ **Q. affinis**
   6. Leaf base round or obtuse; mature leaves 2.4–2.6 long as wide _____ **Q. depressa**

1. Abaxial leaf surface with abundant and persistent long angular trichomes, sometimes trichomes detaching with age.
   7. Abaxial leaf surface sparingly pubescent or glabrescent; if sparingly pubescent, at low magnifications the epidermis could be seen through the trichomes
      8. Trichomes on abaxial leaf surface have a punctate appearance; trichomes fasciculate contorted.
         9. Leaves elliptic-oblong, always entire, veins 6–16 _____ **Q. mexicana**
         9. Leaves elliptic lanceolate, elliptic-oblanceolate, sometimes obovate or ovate, entire or toothed, veins 5–8 _____ **Q. eduardii**
      8. Trichomes on abaxial leaf surface have a floccose or arachnoid appearance; trichomes fasciculate stipitate, fasciculate sessile simple, or multiradiate.
         10. Leaves orbicular, orbicular-pandurate, or broadly obovate; twigs 4–8 mm thick.
            11. Mature leaves with 4–8 teeth; infructescence up to 6 mm long bearing 1–2 fruits _____ **Q. tarahumara**
            11. Mature leaves with 13–19 teeth; infructescence from 4.7 to 15 cm long bearing 3–9 fruits _____ **Q. radiata**
         10. Leaves elliptic, lanceolate, ovate or obovate; twigs 0.75–4(–5) mm thick.
            12. Fruit cupule with the margin involute; cupule diameter 20–28 mm; secondary veins 10–19 _____ **Q. planipocula**
            12. Fruit cupule with the margin straight; cupule diameter 7–15 mm; secondary veins 4–12.
               13. Fruits with annual maturation; bullate epidermis on the abaxial leaf surface; secondary veins 5–12.
                  14. Leaves obovate to elliptic; trichomes on the abaxial leaf surface fasciculate sessile or fasciculate shortly stipitate; leaf margin toothed; distributed in the Sierra Madre Orienta _____ **Q. hirtifolia**
                  14. Leaves elliptic-lanceolate, elliptic-oblanceolate, sometimes obovate or ovate; trichomes on the abaxial leaf surface fasciculate distinctly stipitate; leaf margin entire or entire-aristate; distributed in the Sierra Madre Occidental _____ **Q. aristata**
               13. Fruits with biennial maturation; smooth epidermis on the abaxial leaf surface; secondary veins 4–5.
                  15. Abaxial leaf surface appearing glabrous but with two types of glandular nontrichomes visible at 10×: small multiradiate of short rays distributed on the abaxial lamina and fasciculate stipitate trichomes confined to the secondary vein axils _____ **Q. hintoniorum**
                  15. Abaxial leaf surface pubescent but the trichomes detach with age; trichomes fasciculate sessile simple with long intertwined rays distributed throughout the lamina _____ **Q. hypoxantha**

7. Abaxial leaf surface densely pubescent, the epidermis completely covered with trichomes.
   16. Leaves elliptic, lanceolate, oblanceolate or ovate.
      17. Leaf margin always entire without aristae
         18. Abaxial leaf surface densely pubescent, the indumentum whitish, trichomes multiradiate or simple stellate but appearing fasciculate sessile at 10×; apex acute or acuminate.
            19. Leaf margin flat; mature leaves 2.6–3 times long as wide; petiole 2–6 mm long _____ **Q. durifolia**
            19. Leaf margin revolute; mature leaves 3.75–5 times long as wide; petiole 5–15 mm long _____ **Q. hypoleucoides**
         18. Abaxial leaf surface loosely pubescent, the indumentum pale yellow, trichomes clearly fasciculate stipitate at 10×; apex rounded or obtuse.
            20. Mature leaves about 2.5 times longer than wide; cupule hemispheric or tur-

binate, the cupule margin not involute; current year twigs with fasciculate sessile and fasciculate stipitate trichomes _____ **Q. × dysophylla**

20. Mature leaves 4–4.5 times longer than wide; cupule hemispheric with involute margin; current year twigs with fasciculate sessile and multiradiate trichomes _____ **Q. crassipes**

17. Leaf margin mainly toothed, rarely entire with aristae.
    21. Twigs 3–5 mm thick; abaxial leaf surface with fasciculate stipitate trichomes; cup very shallow up to 5 mm tall, enclosing 1/4 of the nut _____ **Q. hintonii**
    21. Twigs 1–3 mm thick; abaxial leaf surface with fasciculate sessile simple, multiradiate, or fasciculate sessile crested trichomes; cup hemispheric 5–12 mm tall, enclosing 1/3 to 1/2 of the nut.
        22. Abaxial leaf surface with fasciculate sessile trichomes of 6 to 10 long intertwined rays.
            23. Petioles 3–5(–7) mm long; fasciculate sessile trichomes twisted at the base and detaching with age; leaf margin slightly revolute _____ **Q. coahuilensis**
            23. Petioles 5–25 mm long; fasciculate sessile trichomes not twisted at the base and persisting with age; leaf margin flat _____ **Q. castanea**
        22. Abaxial leaf surface with multiradiate or fasciculate sessile crested trichomes of 20–22 short rays.
            24. Leaf base decurrent or cuneate; leaf tapering toward the apex; leaf margin not revolute _____ **Q. scytophylla.**
            24. Leaf base rounded, subcordate or cordate; leaf apex acute or obtuse; leaf margin revolute _____ **Q. sideroxyla**

16. Leaves obovate, suborbicular, orbicular, or very broadly elliptic.
    25. The indumentum on the abaxial leaf surfaces detaches with age; twigs 0.75–1 mm thick; petioles glabrous, reddish _____ **Q. hypoxantha**
    25. The indumentum on the abaxial leaf surface remains attached; twigs 2–13 mm thick; petioles densely pubescent, pubescent, or glabrescent.
        26. Petioles 0.4–25 mm long; cup 7–9 mm wide, 4–5 mm tall; acorn 7–11 mm long, 6–8 mm wide _____ **Q. conzattii**
        26. Petioles 25–37 mm long; cup 8–24 mm wide, 5–15 mm tall; acorn 10–24 mm long, 7–21 mm wide.
            27. Twigs of the season 8–13 mm thick; infructescences 3.5 to 10 cm long bearing 6–10 fruits _____ **Q. urbanii**
            27. Twigs of the season 2.5–6.0 mm thick; infructescences less than 2 cm long bearing 1–2 fruits.
                28. Indumentum on the abaxial leaf surface white or pale yellow; leaves with 12–17 teeth; sparse glandular trichomes on the abaxial leaf surface _____ **Q. candicans**
                28. Indumentum on the abaxial leaf surface yellow or yellow-brownish; leaves with 1–11 teeth; abundant glandular trichomes on the abaxial leaf surface.
                    29. Abaxial leaf surface with a felted indumentum composed of multiradiate trichomes with straight rays; rim of cupule involute _____ **Q. fulva**
                    29. Abaxial leaf surface with a woolly indumentum composed of fasciculate trichomes with long tortuous rays; rim of cupule straight.
                        30. Mature leaves deciduous; trichomes on the abaxial leaf surface fasciculate stipitate _____ **Q. crassifolia**
                        30. Mature leaves evergreen; trichomes on the abaxial leaf surface fasciculate sessile simple _____ **Q. mcvaughii**

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THOMAS WALTER TYPIFICATION PROJECT, I. OBSERVATIONS ON THE JOHN FRASER FOLIO

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ABSTRACT

The Natural History Museum, London, is the repository of a large volume containing plants collected by John Fraser in the southeastern United States in the 1780s and commonly known as the "Walter Herbarium." The importance of this collection is that many of its specimens were seen and perhaps used by Thomas Walter, author of *Flora Caroliniana*, the first American flora to adopt Linnaean binomials and classification. A description is provided here of this folio and the collection it contains.

RESUMEN

El Natural History Museum de Londres, es el depositario de un gran volumen que contiene plantas colectadas por John Fraser en el sudeste de los Estados Unidos en los 1780s y conocido normalmente como el "Walter Herbarium." La importancia de esta colección radical en que muchos de sus especimenes fueros vistos y quizás usados por Thomas Walter, autor de la *Flora Caroliniana*, la primera flora americana en adoptar la clasificación Linneana y la nomenclatura binomial. Se hace una descripción de este volumen y la colección que contiene.

The Thomas Walter Typification Project is the term now given of an effort, extended intermittently over forty years, to bring understanding and nomenclatural precision to the many plant names published by Thomas Walter in his pioneer *Flora Caroliniana* (1788). Walter, an English rice-plantation owner and amateur but skilled botanist, resident of South Carolina, was the first to prepare a flora of American plants utilizing Linnaeus's binomial nomenclature and sexual system of classification. A brief but close relationship developed between Walter and John Fraser, a Scottish plant explorer who in the late 1780s gathered numerous specimens from the southeastern United States into a large folio herbarium now held by the Natural History Museum, London. The specimens of this herbarium were seen and may in part have been used by Walter in preparation of the diagnoses of his new species. The present report is an account of the physical characteristics of this historic collection.

The information of this report is derived from notes taken during a two-week examination of the folio by the present author in July 1984, and from 8x10 glossy photos enlarged from negatives made of the folio by Dr. Bernice G. Schubert in November and December 1946 (Fernald & Schubert 1948). (Commercial microfiches distributed in 1985 were of lesser clarity. Digital images prepared in 2005 were not yet available.) Though much remains unknown, many aspects of the interrelated lives and works of Thomas Walter and John Fraser have been documented by Britten (1921), Coker (1910), Hogg (1852), Maxon (1936), Rembert (1980), Simpson et al. (1997), Small (1935), and Ward (1962 1977).

The specimens are mounted on the pages of a large book, a folio, 54.5 cm tall, 38 cm wide, about 8 cm thick, bound in green cloth and half-leather with 5 transverse raised bands and several thin gold lines. The pages are 52 cm by 35.5 cm, of heavy linen-rag watermarked paper, bound permanently along a lateral margin. The book is of commer-

cial origin, manufactured in advance of its present use; it was not made by binding together separate sheets to which the plants had been attached. Two initial pages are unnumbered; each subsequent page has been numbered by hand near its upper margin. The folio consists of 119 numbered pages (not 117, as reported); two numbers (61 and 62) were used twice.

The frontispiece, the unnumbered first page of the folio, bears an attached sheet (right-diagonals indicate new lines; left diagonals reflect superscripted letters): "The Herbarium of Tho\s Walter Esq. of South Carolina. / Author of the Flora Caroliniana, pub. 1788 / Presented May 23, 1849, to the / Linnean Society of London, by John Fraser, / son of John Fraser, the indefatigable / North American Botanical Collector, / from the years 1786 to 1811. He died / in London, the latter year." This slip (as believed by James Britten 1921) is in the hand of Fraser's son, John Fraser fil. A second, unknown writer has restated these words by inscription onto the page itself: "The Herbarium / of Thomas Walter / author of the / "Flora Caroliniana." / Presented to the Linnean Society, 23 May 1849, / and purchased at the sale of the Society's / Surplus Collections in 1863 (for 15/.)." The frontispiece also bears a detailed listing (probably by Britten) of the persons, into the 20th century, whose annotations are to be found within the folio.

The title page of the folio, also unnumbered, bears the boldly written words, "Walter's Herbarium," the dates "1786–1788," and the initials, "J.F." The hand is that of John Fraser. The dates encompass the frenetic eighteen months—from September 1786 until March 1788—during which Fraser traveled and collected in the American Southeast.

The plants of the collection are mounted (counterintuitively) on the left-hand pages of the opened folio. The herbarium consists of 690 specimens (of which three are represented only by their labels and by stains on the page to which they had been attached). The specimens are mounted with as few as 1 and as many as 12 on a single page (an average of 5.8 specimens per page).

For clarity of reference in present and future study, images (xeroxes from photos) of the specimens have been enumerated by two-part designators: each individual specimen is given the number of the page on which it is mounted, followed by a capital letter. (The two pages with duplicated numbering, p. 61 and p. 62, are distinguished by suffixes "a" and "b.") The specimens, insofar as their arrangement on the page permits, have been assigned a designator in alphabetical order, from upper left to upper right, second-row left to second-row right, down the page. A copy of the images showing the assigned designators has been provided to the Natural History Museum, for placement with the folio. These designators are suggested for use in specimen citation, to replace the use of page numbers or other accompanying numbers seen on many labels, as resorted to by other authors. The designators are employed in the present discussion where appropriate.

Nearly all specimens are accompanied by a small label. (A very few have no label; a few have either two labels, or a label clearly belonging with another specimen.) The labels vary in proportion and dimension, but are mostly of horizontal rectangles, 5 to 8 cm long, 2 to 5 cm high. All have clearly been individually and somewhat roughly cut from other sheets. A few (e.g., 41-E, 51-A, 65-A, 71-A, 80-A, 83-A, 83-E) have been folded transversely, the lower half tucked behind the upper half which bears the writing. Two distinct paper stocks were used for the labels, both of "laid paper," formed from a linen slurry: the one thin, tan, with laid-lines spaced ±9 per cm; the other heavier, whiter, with laid-lines ±7 per cm.

Most of the specimens are attached to the label by one slit or more often two parallel

slits cut in the label, with the plant stem passed under the resulting strap. At times the slits are in the form of shallow V's (e.g., spms. 24-B, 31-C, 32-C, 34-B, 61a-F), indicating they were cut by folding the label, then making the two cuts with two snips of a scissors. Frequently part of the writing on the slip is beneath part of the specimen, obviously having been inscribed prior to attachment of the plant. A few of the specimens have been attached to the label by slender pins (e.g., 46-B, 60-F, 61a-A, 92-J, 105-C). Others have been given firmer mounting, either to the label or to the underlying sheet, by conventional narrow tape strips.

A significant achievement of the Project has been the determination of nearly all of the handwritings on the labels. Yet, for reasons explained elsewhere (Ward, in press), this information is of less value than might be assumed for determination of the collector of the accompanying specimen or for prediction of its use by Thomas Walter in forming the diagnoses of his *Flora*.

Two handwritings predominate on the labels: Thomas Walter (ca. 1740–1789), and John Fraser (1750–1811). The hand of Fraser's son, John Fraser (1780–1861) [not "1799–1860?"—Fernald & Schubert 1948] also appears to be present, though rarely. External evidence of these hands is provided by a 158-word letter written by Walter in 1783 and reproduced by Ewan (1979), and by a 48-word letter written by Fraser's son in 1818 in the Autograph Collection of the Natural History Museum. Fraser's hand is established by the few words and dates of the title page and by occasional brief, initialed notes accompanying the specimens (e.g., 67-A, 78-E). The third hand probably of Fraser fil. differs markedly from that of Fraser and also somewhat from that of Walter. It is found on a few labels (e.g., 8-C, 12-F, 27-D, 38-J, 46-C, 61b-D, 105-C, 115-G). Numbering of the pages of the folio may also have been by Fraser fil.; these numbers are not in the hand of Fraser sr.

Once determination was made that two writers were responsible for the great majority of the labels, most of the handwriting could be assigned. Past authors have referred in general terms to similarities with that of Walter, Fraser, or Fraser's son, but few authors have claimed which hands were found in association with specific specimens, and none are known to have based nomenclatural arguments on such identifications. [Blake (1915:130) correctly identified Walter's hand on four labels, but wrongly concluded "most of the remaining labels are in another hand, which from its agreement with some writing on the title page of the volume may be affirmed with considerable certainty to be that of John Fraser himself.] Yet close—and tediously prolonged—examination of the handwriting of the labels and of the available handwriting samples does usually permit certain identification.

John Fraser's hand in most cases is unambiguous. It is a smoothly flowing script, with the letters consistently formed and widely spaced. His capital "A" is of the classic "inverted V" and uniformly shows the cross-bar sweeping far left across the ascent. His capital "C" is always shaped with both its beginning and terminus well to the left of the figure. His capital "P" is initiated by a strong upstroke, sharply reversed to a downstroke, again reversed to form a clockwise loop. Many of his other capital letters also show distinctive features, though his lower case letters are largely of standard form. He is unfailing in his practice of using capitals for the initial letters of both genera and epithets. His hand is of an extrovert—if this term can be applied to a writing style—fitting the man of confidence and courage his travels and ventures show him to have been.

Thomas Walter's hand is far more cautious, cramped, and poorly, unevenly formed. His capital "A" is at times an "inverted V," but his cross-bar is formed separately and

scarcely touches the ascent; for many of his plant names his capital "A" is merely lower case writ large. His capital "C" is of the same form as Fraser's, but only the beginning is from the left; the lower terminus invariably links with the next letter. His capital "P" is of a smooth clockwise swirl, with the initial stroke directed downward. With few exceptions his epithets are not capitalized. His hand in general is that of a busy, quick thinking person, not overly concerned with the niceties of precise letter formation; in modern days his script might have been that of a doctor.

A readily available sample of the two handwritings is given in photographs shown by Faden (1989:46–47). There, the single word "*Commelina*" is written on the label of a specimen of *C. erecta* by Walter, and on the label of a specimen of *C. caroliniana* by Fraser. The Walter label also bears "305," a number written by Fraser.

John Fraser fil.'s hand is poorly understood because of its infrequent appearance. Though it is unlikely to be mistaken for that of John Fraser sr., brief sequences of letters (as in plant names or brief notes) may not show marked contrast with that of Walter. A character that may be useful is the "square r" here attributed to Fraser fil., while the lowercase "r" of both Fraser sr. and Walter is usually an abrupt simple upward pip.

More than half of the labels (371, or 54%) bear three-digit (rarely two-digit) numbers in a darker ink and a coarser pen, and seem to have been written prior to other markings. The hand forming these numbers is that of John Fraser; his distinctively malformed "8" appears also as part of the date given on the title page of the folio. (Representative specimens so marked: 1-H, 27-C, 34-D, 51-B, 54-D, 59-E, 66-C, 101-C, 103-F, 107-A.) Britten (1921) was unable to discover the use to which Fraser put these numbers, nor have others suggested any logical purpose. The numbers correspond neither to the present arrangement of the specimens nor to the sequence of Walter's *Flora* (nor presumably to its parent manuscript). Many of these numbers have been struck by a single diagonal slash; most of the rest are accompanied by a small checkmark. No numbers are repeated. The numbers may differ in size between two adjacent specimens (e.g., 62a-B and 62a-C, 94-D and 94-E), demonstrating that specimens now adjacent in the herbarium were numbered at different times. Frequently the numbers are partially cut away at edge of the label (e.g., 38-I, 50-E, 80-D, 84-A, 86-C, 92-A, 105-B, 108-F). These characteristics support the speculation that Fraser's numbers served as field references, perhaps coupled to a now-lost separate record of source and date, the pages later cut to their present dimensions and used as permanent labels. The few two-digit numbers of this series (six exceptions, but not clearly in the same hand), together with knowledge that Fraser spent earlier years (1780–1784) in Newfoundland where he also studied plants (Fraser 1789; Hogg 1852), suggests that these numbers may have been a continuing enumeration of his collections begun before he first came to the Carolinas. Certainly, aside from their initial purpose, their presence on the label indicates that the specimen is of Fraser's collection, whether or not it was later seen by Thomas Walter.

Another series of numbers seems not to have been noted. Each number of this small class (20 numbers) is preceded by a capital "F" or "FC." All are clear references to the numbered genera in *Flora Caroliniana*. Examples: 100-C is named "*Staphylea Trifolia*" and numbered "F 132," while genus 132 is *Staphylea*; 106-A is named "*Verbena Urticifolia*" and numbered "F 236," while genus 236 is *Verbena* with the single species *V. urticifolia*; 116-C and 116-D both bear the name "*Syntherisma*" and are numbered "F 35," while genus 35 is *Syntherisma* (= *Digitaria*). (Further examples: 32-A, 32-B, 32-C, 32-D, 38-J, 48-C, 115-G, 117-A, 117-D, 117-E.) Most of the numbers occur in clusters (e.g., 32-A thru 32-D, 101-A

thru 101-G, 115-G thru 117-E), indicating they were assigned after the specimens were arranged in the herbarium. The hand inscribing this series of numbers is probably that of Fraser (e.g., 38-J, 48-C, 100-C), though at times the "F" seems unlike his. Possibly it is that of his son; it is not that of Walter. These numbers were certainly assigned after publication of *Flora Caroliniana*, or at least after access to the completed manuscript. This second series of numbers appears to have been a partial, never completed attempt to match the specimens collected by Fraser to the appropriate genus as numbered by Walter.

Within the folio the specimens are arranged in an alphabetical sequence, as determined by the names borne by the original labels. These names, in turn, are largely those used in Walter's *Flora Caroliniana* (1788). [The few exceptions are usually in the hand of John Fraser and bear a name from Linnaeus that was not used by Walter (e.g., 37-G, "*Cornus canadensis*"; 52-E, "*Globularia nudicaulis*"; 58-C, "*Helonias bullata*"), or a comment by Fraser or Walter in place of a name [e.g., 38-D, "*Corypha arborea*" (= *Sabal palmetto*); 43-B, "*Erythronium Dens Canis*" (= *E. americanum*); 55-C, "*Hedysarum Flore magnus*" (= *Desmodium cuspidatum*); 67-D, "*Lupinus affinis*" (= *Crotalaria rotundifolia*); 72-A, "*Mespilus Large Cock Spur*" (= *Crataegus crus-galli*); 98-D, "*Smilax Baccis albidis*" (= *Smilax laurifolia*)].

Of the specimens bearing an identification on the label (either complete, or only to genus), 345 (50.1%) bear Walter's hand, 230 (33.4%) bear Fraser's. Often the hands of Walter and of Fraser are found on the same label. On 49 labels Walter identified the specimen to genus and Fraser completed the naming by adding the species. On none of the labels did Fraser identify the specimen to genus, with Walter adding the species.

Handwritings by other persons have been added over the years, usually in the form of identifications. They may be on separate slips, on the adjacent sheet, or on the original label itself. Those writers identified on the frontispiece of the folio (by James Britten) are: Oakes Ames, Sidney F. Blake, Nathaniel Lord Britton, Alva A. Eaton, Asa Gray, Albert S. Hitchcock, Charles S. Sargent, James E. Smith, and Anna M. Vail. Others include James Britten, James E. Dandy, Merritt Lyndon Fernald, William T. Gillis, A. J. Kosterman, John Lewis, Mildred E. Mathias, and Charles A. Weatherby. More recent annotations (since 1983) are by Joseph Ewan, David K. Northington, David H. Rembert, Daniel B. Ward, and others.

Identification of the specimens is no easy task. As noted in 1839 by Asa Gray (J.L. Gray 1893), many of the specimens are "mere bits," small vegetative fragments, single leaves or single flowers, often wholly unidentifiable from photographs and scarcely less so by direct examination without painstaking comparison to known materials. Significant efforts to identify more than single genera by direct examination are few. Hitchcock (1905) reviewed Walter's grasses and matched many of their names with Fraser's specimens. Blake (1915) discussed 22 Walter names and their corresponding specimens and made new combinations where indicated. Fernald & Schubert (1948), working from photographs, identified—not always correctly—19 specimens in the herbarium. Others have examined the species of individual genera and published their conclusions. Still others, notably Oakes Ames with the orchids, and Asa Gray and David H. Rembert with large parts of the entire herbarium, have given significant time to identifying the specimens, but have left no record other than their annotations and notes.

At the present writing perhaps one third of the specimens has been given a creditable identification, one third a tentative judgment, and one third no more than a cautious assignment of genus. Complete identifications must await opportunity for study by persons who have simultaneous access to the Fraser specimens and to a convenient reference collection.

Only two of the 690 specimens bear a date on the original label. Spm. 78-E, probably *Platanthera flava*, is atypically instructive: "Orchis / found near the / Table Mountains / 11th June / 1787 / JF." The hand, confirmed by the initials, is that of John Fraser. Spm. 100-F, *Gillenia trifoliata*, is briefly informative though lacking the year of collection: "16 June / Indian Emetic," written by Fraser, followed by "Spiraea trifoliata," written by Walter.

Equally few specimens bear a geographic source on the original label. Only two labels give locations; both are in Fraser's hand. As noted, spm. 78-E, probably *Platanthera flava*, was collected near the "Table Mountains," perhaps Table Rock, Pickens Co., South Carolina (less likely: Table Rock, Burke Co., North Carolina). Spm. 67-A, *Lupinus villosus*, was labeled "Blue Flowering / Lupinus / Pilosus / Found on y\e / Border of y\e / Altamayhaw / J.F." This of course is the Altamaha River, which flows through southeastern Georgia. The first of these locations is about 360 km northwest of Fraser's base in Charleston; the second is about 240 km to the south. The distance between these locations, together with the certainty that these summer-flowering species must both have been collected in 1787, is a measure of John Fraser's energy and dedication.

Most of the specimens (624, or 91%) are labeled with an identification—a genus and species, or a genus only. 328 (48%) of the specimens are fully identified (to genus and species), by either Walter or Fraser or by both (where Walter wrote the genus and Fraser added the epithet). Nearly half of the specimens (296, or 43%) are identified only to genus, 183 of them (27%) by Walter, 113 (16%) by Fraser. 64 (9%) of the specimens bear labels, but were not identified.

The labels of occasional specimens carry comments or information other than the identification. Walter frequently appeared not to recognize the plant, but wrote a brief Latin diagnosis which reflects his familiarity with Linnaeus' sexual system of classification. Some examples: 4-C, *Ptilimnium capillaceum*–"Ammi majus sp. nova?"; 55-C, *Desmodium cuspidatum*–"Hedysarum Flore magnus"; 60-F, *Silene stellata*–"ignota"; 61b-B, *Iva imbricata*–"Iva ? nova"; 67-D, *Crotalaria rotundifolia*–"Lupinus affinis"; 75-F, *Nelumbo lutea*–"The Great Nymphaea"; 86-B, *Myriophyllum pinnatum*–"Potamogeton monoicum"; 87-D, *Physostegia virginiana*–"Prasium nov"; 89-A, *Cynanchum angustifolium*–"Pentand[ria] Digyn[ia] bifollic"; 90-B, *Quercus michauxii*–"Quercus nova"; 91-A, *Brunnichia ovata*–"Rajania (monoica)"; 97-C, *Bumelia lanuginosa*–"fol. angustis obovatis integris subtus tomentosus"; 98-D, *Smilax laurifolia*–"Smilax Baccis albidis"; 106-E, *Phyla nodiflora*–"Verbena nodiflora Didynamia gymnosperm disperma"; 108-D, *Viola villosa*–"Viola Fol. pubescent"; 114-E, *Juncus effusus*–"an Juncus"; 117-A, *Decodon verticillatus*–"Decand monogyn nov G. aquatic"; 117-B, *Cynoctonum sessilifolium*–"Genus nov Pentand digyn."

Fraser's distinctive script usually appears to be of observations made of the plants in the field. When he ventures into Latin he is clearly in unfamiliar country. Britten (1921) gently noted Fraser's limited linguistic skill where "nova genera" was used "as a singular," trusting his classic-trained readers to understand. Some of Fraser's notations: 1-D, *Viburnum dentatum*–"not in y\e Flora"; 11-B, *Asclepias* sp.–"Dove Coloured"; 12-G, *Aster concolor*–"Aster Dark Blue Flower"; 22-C, *Psoralea canescens*–"Buchnera americana native name Buck root"; 38-G, *Croton punctatus*–"Croton Maritimum Nova"; 52-I, (unidentified)–"Granadilla not in y\e flora"; 62a-A, *Aesculus parviflora*–"Juglans Alba nova"; 67-A, *Lupinus villosus*–"Blue Flowering Lupinus Pilosus Found on y\e Border of y\e Altamayhaw J.F."; 67-C, *Lupinus perennis*–"Lupinus Perrenis [sic]"; 72-A, *Crataegus crus-galli*–"Mespilus Large Cock Spur"; 72-B, *Crataegus uniflora*–"Mespilus Small Cock Spur";

92-K, *Rhododendron minus*–"Leaves like y\e Kalmia? Latifolia grows on y\e Mountain in decid. y\e Est\n & Wes\n Waters"; 93-C, *Salix humilis*–"Salix Minor? of Fraser"; 100-K, *Arenaria uniflora*–"No Name"; 106-F, *Verbena tenuisecta*–"Nova Genera"; 108-C, *Viola primulifolia*–"Viola White Flowers Downy Leaf"; 110-A, *Vitis labruska*–"Vitis? Labruska Fox Grape"; 116-B, *Eriogonum tomentosum*–"Sophoranthus nov genera"; 117-C, *Lachnanthes caroliniana*–"Nova Genera"; 117-E, *Carphephorus* sp.–"Genera Nova."

Comments on a few labels are not in Fraser's hand nor in Walter's, and show involvement of a third person: 8-C, *Stylosanthes biflora*–"Arachis ground nut"; 12-F, *Aster* sp.–"Aster grows 16 feet high"; 46-C, *Conoclinium coelestinum*–"Bright violet blue: said to be a specific for the venereal complaint"; 105-C, *Vaccinium arboreum*–"A Vaccinium 5 miles from Cranberry measured 50 feet high"; 115-G, *Planera aquatica*–"Monoecia Triandria G. nova."

The handwriting on these last-cited labels, and a few others, poses a puzzling, unresolved question. The content of most suggests they were written at the time of collection. Their subject matter is wholly different from the technical comments recorded by Walter. And the hand is quite incongruous with that of Fraser sr. The "square r" of some (8-C, 12-F, 27-D, 38-J, 46-C, 105-C) would seem to be that of Fraser fil. Yet John Fraser, the son, did not accompany his father to the Americas until 1800 (Hogg 1852), more than a decade after Fraser's 1786–1788 trip, and eleven years after Walter's death. Could these notations have been made by Fraser fil. on his father's labels after they were brought to England? Or is it possible these specimens (and perhaps others) were obtained, and annotated, by Fraser fil. on his 1800 trip to the Americas with his father?

The labeling of one species confirms an involvement of a third person in identification and possibly a fourth in mounting of the specimens. A mint, *Trichostema dichotomum*, is represented by two collections, 61b-D and 103-F. Both are labeled with its name. The label of 103-F is in Walter's hand, and is spelled conventionally. But 61b-D is in another hand, neither Walter's nor Fraser's. The style of the capital "T" is so different that the mounter of the specimens, intending to arrange them in alphabetical order (as was done with 103-F), but seemingly misreading the convoluted script of the initial letter, has placed 61b-D between "*Iva*" and "*Illicium*." Further, the writer of that label transcribed its epithet as "*dichotoma*," suggesting one of sufficient education to perceive an apparent error of gender mismatch between epithet and genus, yet without adequate classic background to understand that "*-stema*" is a neuter root. Even more, the mounter himself must have been of limited experience not to have recognized the distinctive specimen as one already found elsewhere in the folio. With certainty, Fraser sr. neither formed this label nor was involved in its mounting.

One specimen is wholly aberrant. Spm. 102-A is a branched structure mounted alone on a full page. It is a gorgonian (Gorgoniidae–coral, s.l.). Enlarged bodies on its branches are barnacles (Archaeobalanidae; *Conopea* sp.). It was labeled "Sea Plant" in Fraser's hand.

The physical processing of the specimens into the present folio remains poorly understood. Walter, of course, was not involved. Fraser, perhaps soon after his return to England in March 1788, must have acquired the empty folio and, as indicated by his writing on the title page, established its goal. It is often forgotten that the present herbarium of 690 plants is only a subset of the "upwards of thirty thousand dried specimens of plants" Fraser (1789) claimed to have gathered during his 1786–1788 trip to the Americas. An unknown number, perhaps the greater part, were sold by Fraser (1789) to Charles Louis L'Heritier, a wealthy French botanist, and are now in the Lamarck herbarium, Paris. The

basis is unknown by which Fraser, or his sons during his absence on later trips to the Americas, Cuba, and Russia (Hogg 1852; Simpson et al. 1997), selected from this larger collection the plants to be retained in the "Walter Herbarium."

The historic importance of this early sampling of the plants of Georgia and the Carolinas is unquestioned. America is fortunate the fates have preserved this fragmentary glimpse of its vegetation as it appeared before the full impact of modern civilization. Even so, the larger value of the John Fraser folio and the specimens it contains lies in the degree it supports the writing of Thomas Walter and his *Flora Caroliniana*. The nomenclatural basis for Walter's work and its relation to Fraser's herbarium is to be discussed in subsequent reports of the Thomas Walter Typification Project.

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EVIDENCE FOR HYBRIDIZATION BETWEEN TWO SYMPATRIC VIOLET SPECIES, *VIOLA GRAHAMII* AND *V. HOOKERIANA* (VIOLACEAE), IN CENTRAL MEXICO

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ABSTRACT

Viola hookeriana and *V. grahamii* (Violaceae) are closely related species in section *Viola*, subsection *Mexicanae* occurring in mountainous habitats across much of central Mexico. In various locations, these species grow sympatrically, and the occurrence of many individuals with intermediate morphological characters has suggested hybridization between these species. Using a combination of morphological, ecological, and molecular evidence we evaluated two mixed populations of *V. grahamii* and *V. hookeriana* in mountains surrounding Lake Pátzcuaro in the state of Michoacán to determine the potential of distinct hybrid morphologies, the strength of phenological differences and ecological preferences among the species and putative hybrid, and to evaluate the level of gene flow between the two species. Our results indicate that hybridization is occurring and that hybrids are morphologically distinct from the parental taxa. Pre-mating isolation is weak and has favored extensive hybridization due to largely overlapping blooming times, weak ecological isolation and absence of spatial isolation. Hybrids are morphologically and genetically closer to *Viola grahamii*, but do show unique alleles as well.

RESUMEN

Viola hookeriana y *V. grahamii* (Violaceae) son dos especies pertenecientes a la Subsección *Mexicanae* dentro de la Sección *Viola* del género *Viola*. Estas especies crecen simpátricamente en varias regiones en el centro del México y la presencia de individuos con características intermedias ha sugerido la existencia de hibridización entre las especies. Usando una combinación de datos morfológicos, ecológicos y moleculares evaluamos dos poblaciones mixtas de *V. grahamii* y *V. hookeriana* en las montañas cercanas al lago de Pátzcuaro en el estado de Michoacán en México para determinar la presencia de morfologías características a los híbridos, el grado de diferencias fenológicas y ecológicas entre las especies y el nivel de flujo génico entre ellas. Nuestros resultados indican la presencia de híbridos y que estos son morfológicamente distintos a los padres. Los mecanismos de aislamiento entre las especies parentales no son muy fuertes y esto ha favorecido la hibridización extensa entre ellas debido a tiempos de floración similares, muy poco aislamiento ecológico y la ausencia de separación espacial entre las especies. Los híbridos son morfológicamente y genéticamente mas similares a *Viola grahamii*, pero muestran aleleos que son únicos a ellos.

Hybridization is a common phenomenon in nature, as evidenced by an estimated 70,000 natural interspecific plant hybrids worldwide (Rieseberg & Ellstrand 1993; Judd et al. 1999), and the fact that between 16 and 37% of the plant families reported in different floras contain at least one hybrid taxon (Ellstrand et al. 1996). In some cases, hybridization can lead to the creation of hybrid species and/or introgressants between hybrid derivatives and the parental taxa (Arnold 1992; Rieseberg 1995). The genus *Viola* L. (Violaceae), which comprises about 525–600 species (Clausen 1964; Ballard et al. 1999), is well known for its taxonomic problems due to hybridization and introgression, as well as complex patterns of variation in individual traits (Brainerd 1924; Anderson 1954; Rus-

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sell 1955; Ballard 1994; Krahulcová et al. 1996; Gil-ad 1998; Neuffer et al. 1999; Marcussen & Borgen 2000; Calderón de Rzedowski 2001; Harmaja 2003).

Analysis of herbarium specimens from central Mexico has indicated that hybridization is likely occurring among species belonging to *Viola* subsection *Mexicanae* (Ballard 1994). *Viola* subsection *Mexicanae* W. Becker (sensu Ballard et al. 1999) is a monophyletic group consisting of eight stoloniferous or rosette-forming species: *Viola hemsleyana* G. Calderón, *V. grahamii* Benth., *V. oxyodontis* H.E. Ballard, *V. humilis* H.B. & K., *V. hookeriana* H.B. & K., *V. beamanii* G. Calderón, *V. guatemalensis* W. Becker, *V. nannei* Polak. (Ballard & Sytsma 2000; Ballard et al. 1999), and an additional undescribed species (Ballard, per. obs.). Instances of hybridization have been identified from several localities in central Mexico occurring between *Viola grahamii* and four other members of the group, *V. guatemalensis*, *V. hemsleyana*, *V. hookeriana* and *V. humilis*. Occurrences of these putative hybrids appear to be restricted however to the immediate areas where both parents occur sympatrically.

Viola grahamii (known in Mexico as "hoja de pasmo" or "pensamiento del cerro") is a frequent to locally abundant perennial distributed across much of Mexico. Specifically, it occurs in mountainous regions from northern Mexico south to northern Guatemala, and is one of the most widely distributed members of the subsection *Mexicanae* (Fig. 1). It thrives in dry to mesic sandy loam under varied forest canopy and along stream banks at elevations of 1950–3600 meters (Ballard 1994; Calderón de Rzedowski 2001), and often forms large mats connected via aboveground stolons. It produces chasmogamous flowers at the beginning of the rainy season (June) for approximately four weeks and cleistogamous flowers for several months afterward (June–December) until the onset of the dry season (Cortés-Palomec 2005).

As previously mentioned, one of the four species with which *Viola grahamii* appears to hybridize is *V. hookeriana* (known in Mexico as "violeta"). *Viola hookeriana* is an infrequent to locally common perennial generally growing in small isolated populations across northern and central Mexico (Fig. 1). It grows in mesic loam under mixed deciduous and coniferous forest canopy at elevations between 1700–2500 meters (Ballard 1994; Calderón de Rzedowski 2001). Reproduction occurs via both chasmogamous and cleistogamous flowers and follows a similar pattern to that seen in *V. grahamii* (Cortés-Palomec, pers. obs.).

Viola hookeriana and *V. grahamii* are divergent in several characters: growth habit, flower structure, and foliage, and can be separated without difficulty in both herbarium specimens and living populations (Table 1) (Ballard 1994). The putative hybrids have been identified in areas of overlapping distribution of the two species (Fig. 1), and are recognizable as exhibiting intermediate morphologies (Ballard 1994).

The goal of our study was to assess the presence and extent of hybridization between *V. grahamii* and *V. hookeriana* in natural populations, and identify intrinsic pre-mating isolation mechanisms that may be functioning between the two species. We examined morphological and phenological differences between the two species, characterized the ecological factors governing where individual species and putative hybrids occur, and surveyed genetic patterns to identify gene flow between species in two study sites in central Mexico where *V. grahamii* and *V. hookeriana* intermingle extensively.

MATERIALS AND METHODS

Site Establishment and Sampling

Two study sites were established in the mountains to the north of Lake Pátzcuaro in the

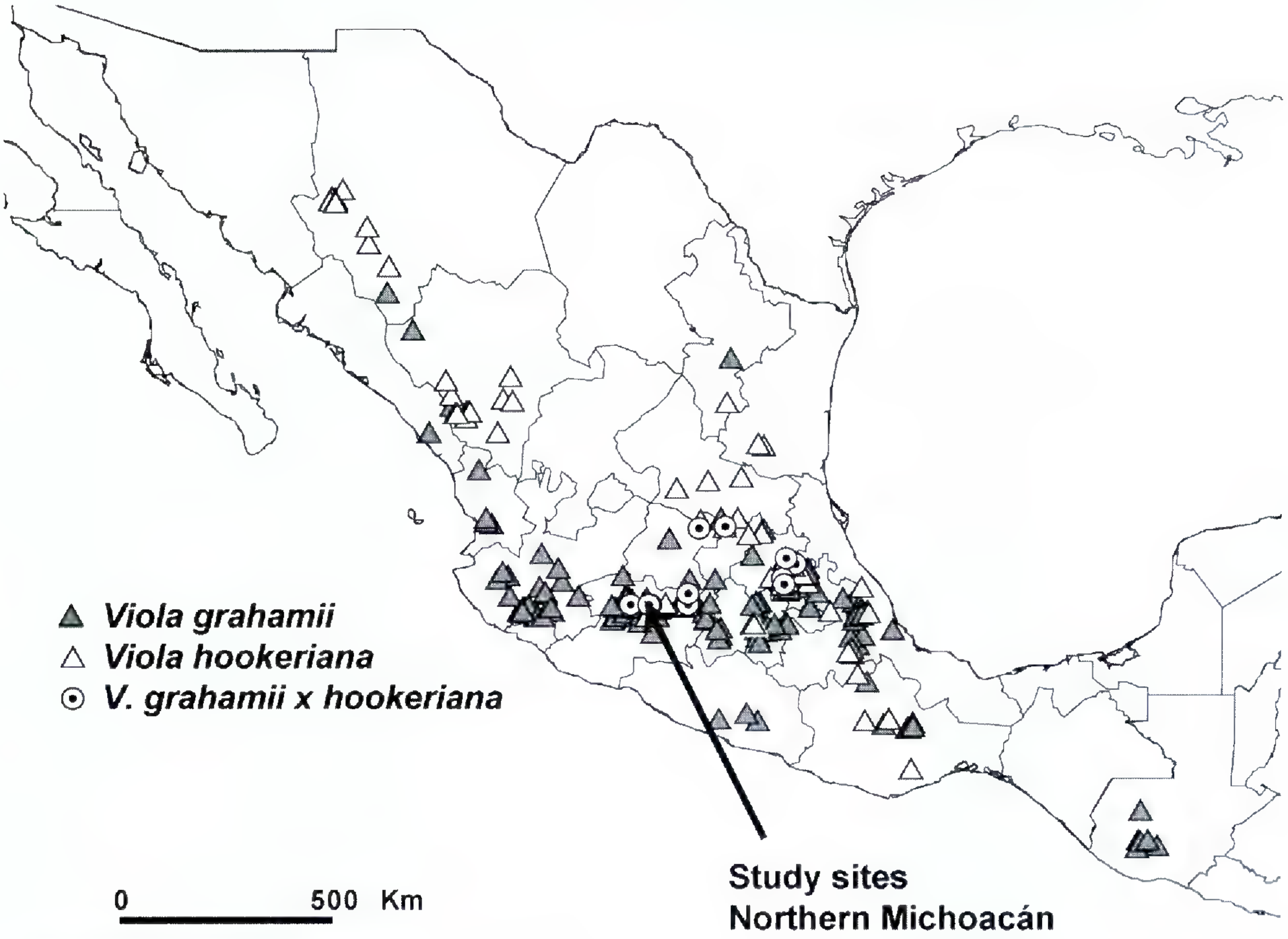


FIG. 1. Distribution of *Viola grahamii*, *V. hookeriana*, and *V. grahamii* × *hookeriana* across Mexico and northern Guatemala. Distribution from Ballard (unpublished data).

municipality of Quiroga, Michoacán, Mexico (Fig. 1). The sites were established in early June 2000 and observations were made weekly over a period of five weeks during the summer rainy season when chasmogamous flower production was most extensive. The two specific sites were chosen due to the presence of abundant populations of the two species and their putative hybrids as identified through a survey of the area conducted earlier in the spring. The first site (Site A) [19°41'57" N; 101°32'27" W] was situated on the lower southern slopes of Mt. Zirate, above the town of Santa Fe de la Laguna. The second site (Site B) [19°42' N; 101°35' W] was located 8 km to the west of Santa Fe de la Laguna (Km 48 on the road from Quiroga to Zacapu (MX-15)). While both sites were located in superficially similar environments, they differed in the level of disturbance and abundance of violet species. *Viola grahamii* was abundant in both sites, but areas of visually pure *V. hookeriana* separated from *V. grahamii* were found only in Site A.

In Site A, four 20 m long transects were established. Two transects were arbitrarily placed through the middle of a visually "pure" population of the parental species (A-T1VG in a *V. grahamii* population and A-T4VH in a *V. hookeriana* population). Two additional transects (A-T2HY and A-T3HY) were placed through areas where putative hybrid plants intermingled with the parental taxa. Ten quadrats (0.5 m^2) were randomly established along each transect with position determined using a random number table. In Site B the same procedure was followed except that only three transects were positioned resulting in a total of 30 quadrats (B-T1VG for *V. grahamii*, B-T3HY of mostly *V. hookeriana* and a mixture of *V. grahamii* and hybrids, and B-T2HY consisting mostly of putative hybrids).

TABLE 1. Comparison of morphological characters used to distinguish between *Viola grahamii* and *V. hookeriana* (on the basis of Ballard 1994). The characters of hybrids are not included since they are not consistent (i.e., hybrids show varying combinations of traits, making them difficult to characterize).

Character	*Viola grahamii*	*Viola hookeriana*
Stolon position	above ground	underground
Stolon nodes	present	absent
Stipule adnation	free or adnate	free
Pubescence on petioles and abaxial surface of leaves	present [abundant]	absent
Leaf shape	ovate-oblong to elliptic	broadly ovate to reniform
Length of pedicels (cm)	3–12	5–21
Calyx pubesence	ciliate	glabrous
Corolla color	white	white, sometimes purplish
Elevation	1950–3600 m	1700–2500 m

For transects representing "pure" parental taxa at each study site, three plants that were not connected via stolons were randomly selected in each of the 10 quadrats. One leaf was removed from each of the three plants and dried in silica gel for later DNA extraction. A second leaf, the largest of each individual, was collected and labeled to correspond to the DNA sample. This leaf was pressed and used for subsequent morphological analysis. The same methodology was used for plants in the putative hybrid/mixed-taxon transects, except that 5 individuals were sampled per quadrat.

Phenology and Pollinator Visitation

In each of the 70 quadrats (40 from Site A, 30 from Site B), the number of individuals present per quadrat and the number of individuals with open chasmogamous flowers were recorded weekly during the five weeks of field observations to interpret phenology. The percentage of flowering individuals, those bearing chasmogamous flowers at some point during the study, was calculated for each visit for the two species and for the putative hybrids to allow for a comparison of phenology among the parental taxa and putative hybrids at both sites. Quadrats with more than one taxon were recorded separately for each taxon and analyzed as separate observations. A Kolmogorov-Smirnov two-sample test was performed in NCSS (Hintze 1999) to compare phenological patterns among taxa at each of the two sites.

Pollinator visitation was assessed during weekly visits to Site A, which was the only site to have clearly differentiated populations of *V. grahamii* and *V. hookeriana*. A total of 40 hours of direct observations of the flowering individuals were recorded with special emphasis made to observe instances of pollinator movement between or among differing taxa. The hours of pollinator observation were equally divided between two daily periods relating to potential insect activity based on the times when previous observations in the area suggested the potential pollinators would be more active, between 8:00 and 11:00 am, and between 12:00 and 3:00 pm.

Ecological Characterization

To determine if the taxa grow in modally different microhabitats, infer whether ecological isolation might reduce gene flow between the species and the putative hybrids, and understand the local distribution of putative hybrids relative to the parents, an ecological characterization of microhabitat in the 70 quadrats was conducted. Soil N, P, K con-

centrations and pH were evaluated using a LaMotte™ Combination Soil Test Kit (LaMotte, Chestertown, MD). Values were given in exact units for pH while values for N, P, and K were determined via a colorimetric test procedure from which concentration could be estimated within a set range, 5–75 ppm for N, 5–100 ppm for P, and 50–200 ppm for K. Due to the inability of obtaining exact concentration values for N, P, and K, these values were range standardized and analyzed in rank form.

Percent soil moisture was recorded using the gravimetric method described by Hadley and Levin (1967), with the modification that soil mass was determined after one week of air drying. Light availability as a direct means of inferring canopy closure was measured using a Model-C spherical densiometer (Vora 1988). Quadrats with more than one taxon were recorded separately for each taxon and analyzed as separate observations. Data were standardized and an analysis of variance was performed in NCSS to test for differences among *V. hookeriana*, *V. grahamii* and putative hybrids.

Morphological Analysis

From the pressed leaves, measurements were taken of the 0°, 30°, 60°, 90°, 120°, 150° and 180° radii, following the procedure outlined by Ballard and Wujek (1994). The center of the leaf was considered to be the point along the midrib opposite the widest part of the leaf blade. Presence or absence of leaf pubescence on the abaxial surface of the leaf, a characteristic considered diagnostic for separating *V. hookeriana* (glabrous) and *V. grahamii* (pubescent), was also recorded. Measurements were standardized and a discriminant analysis (Manly 1994) was performed, both including and excluding visually identified putative hybrids to determine overlap in leaf characters among the two taxa and putative hybrids. The analysis was performed in NCSS using an automatic variable selection procedure. Measurements at 30° and 120° were excluded from the analysis due to colinearity of the data. The canonical scores generated from these analyses were used in an analysis of variance (ANOVA) with a Fisher's LSD pairwise comparison analysis (Zar 1996).

Genetic Analysis

To test the presence of genetic differences among the parental taxa and identify potential gene flow within the putative hybrids, biparentally inherited nuclear markers, inter-simple sequence repeats (ISSRs) were used. ISSR data have proven to be highly effective in detecting hybridization and/or gene flow among closely related species, and to test the hybrid speciation hypothesis (Wolfe et al. 1998a, b; Wolfe & Randle 2001; Archibald et al. 2004; James & Abbott 2005). Additionally these markers are useful in studies of differentiation among closely related species for they are able to utilize some of the variability present at microsatellite loci without the need to develop species-specific microsatellite primers, an advantage when working with species which have not been well-studied genetically.

Genomic DNA was extracted from the silica gel-dried leaves using a Wizard Genomic DNA purification kit (Promega, Madison, WI). Five different ISSR primers (McCauley & Ballard 2002) were initially screened to identify primers which would produce consistent and scorable polymorphic bands among the taxa. Two primers were selected: Wolfe #99B [$(CA)_6GG$] and HB#15 [$(GTG)_3GC$]. These were used for amplification of ISSR products in replicated 25 µl reactions consisting of 1 µg µl^{-1} diluted genomic DNA, 19 µl autoclaved distilled water, 2.4 µl 10× PCR Buffer (Gibco BRL), 2 µl $MgCl_2$ (50 mM, Gibco BRL), 2 µl of dNTP mix (10 mM, Fisher), 0.5 µl of BSA (Bovine Serum Albumin, 4 µg µl^{-1}, Fisher),

0.25 µl primer and 0.25 µl of Taq polymerase (5 U μl^{-1}, Gibco BRL). The polymerase chain reaction was performed in a Stratagene RoboCycler 96 with hot-top (Stratagene Inc, La Jolla, CA) and programmed for 2 min. at 94°C; 40 (primer Wolfe #99b) 44 (primer HB #15) × 30 sec. at 94°C, 45 sec. at 44°C, 1 min. 30 sec. at 72°C; 20 min at 72°C.

PCR products were electrophoresed in a 1.3% agarose gel in 0.5 × TBE buffer with flanking 250 bp ladders (Gibco BRL). Gels were stained with a solution of ethidium bromide in 0.5 × TBE buffer for 20 minutes and imaged under UV light. Gel images were analyzed with BioMax ID image analysis software (Version 2.0.3, Eastman Kodak Company, Rochester, NY) to identify and size fragments. Fragments were scored as present (1) or absent (0), with fragments comigrating at identical rates (± 10 base pairs, the general limit of resolution for agarose gels) considered equivalent. Statistics concerning fragment occurrence, including total fragment number, distribution across taxa, polymorphic and fixed fragments, and number of fragments shared among taxa per site were calculated using TFPGA 1.3 (Miller 1997).

Analysis used three discrete methods to evaluate relationships and similarity among the taxa and putative hybrids. UPGMA cluster analysis and Principal Coordinates Analyses (PCoA) were performed both within and between the two sites using NTSYS ver. 2.02j (Applied Biostatistics Inc.). An Analysis of Molecular Variance (AMOVA) was additionally performed in a hierarchical fashion among species and sites using WINAMOVA 1.55 (Excoffier 1993). All analyses were performed according to the methods described in McCauley and Ballard (2002).

RESULTS

Phenology and Pollinator Visitation

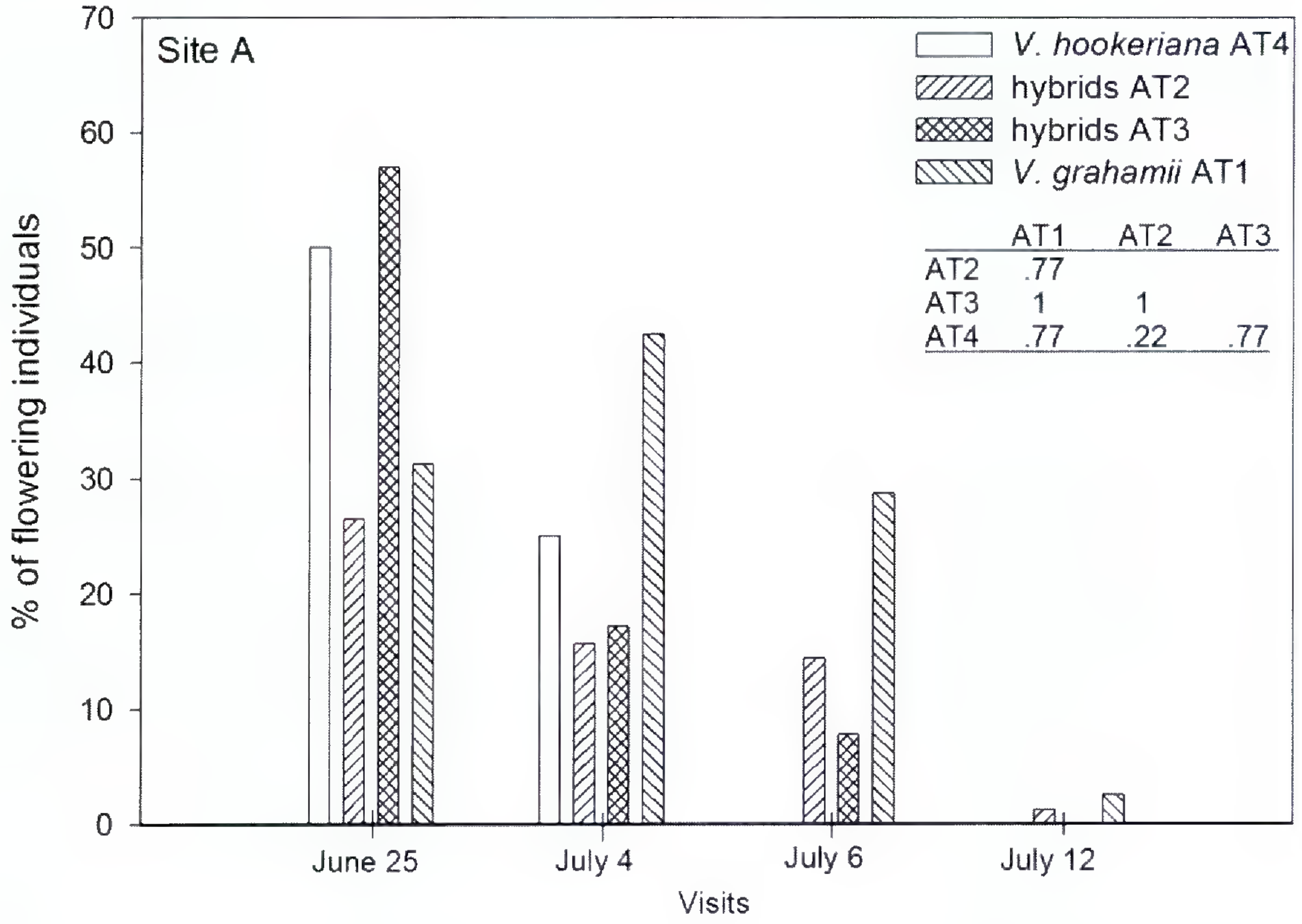
The parental species expressed divergent but non-significant tendencies in blooming time; in fact, in Site A *V. hookeriana* bloomed first, whereas in Site B it bloomed later (Fig. 2). The Kolmogorov-Smirnov two-sample test showed no significant differences among the blooming times of the hybrids and the parental taxa in either site (p values = 1 in some pairwise comparisons) (Fig. 2). No pollinators were observed visiting violets at any time during this study.

Ecology

All three taxa inhabited modally different microhabitat conditions influenced by light and certain nutrients, in all cases where there were significant differences between the taxa, the hybrids grew in intermediate conditions to the parental species. The ANOVA of the ecological factors revealed significant differences in light ($p = 0.02$), P ($p = 0.04$) and K ($p = 0.03$) among *V. hookeriana*, *V. grahamii* and the putative hybrids; moisture ($p = 0.32$), pH ($p = 0.86$) and N ($p = 0.62$) did not differ significantly. *Viola hookeriana* grew in higher concentrations of P, lower concentrations of K and more shaded environments than *V. grahamii* (Table 2).

Leaf Morphology

Two hundred and eighty eight individuals were classified into three groups corresponding to the two parental taxa and the putative hybrid individuals (Fig. 3). The discriminant analysis indicated three marginally distinct groups (Fig. 4), with the GLM ANOVA and the Fisher's LSD Multiple Comparison analysis indicating that they were well-supported and significant ($p < 0.05$) groups.



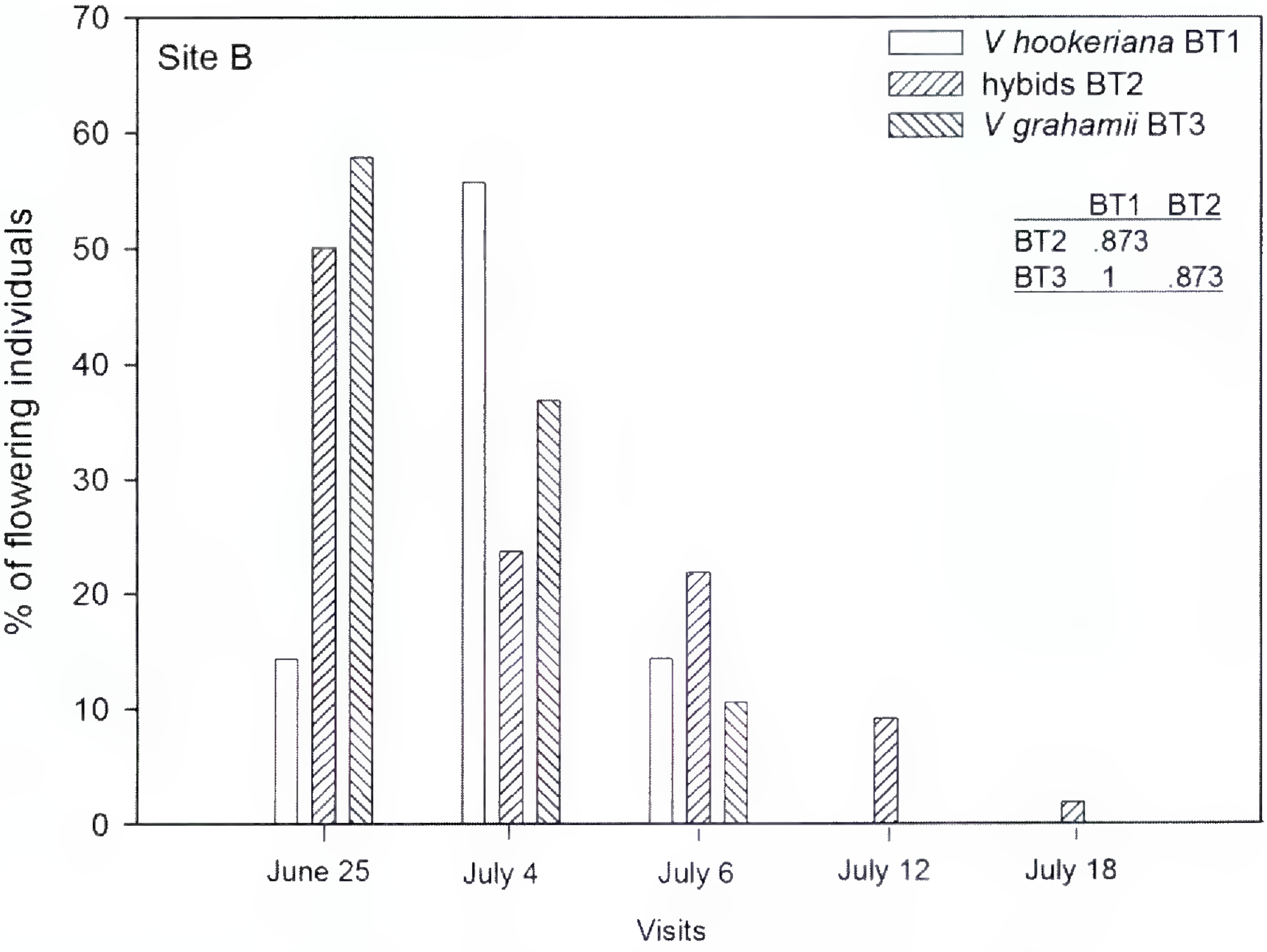


FIG. 2. Histogram of phenology for flowering individuals in two sites of *Viola grahamii*, *V. hookeriana* and *V. grahamii* × *hookeriana*. Abundance of flowering individuals is summarized by transects. *P*-values depicting strength of similarities or differences among taxa using a Kolmogorov-Smirnov two-sample test are shown in the box. VH = *V. hookeriana*, VG = *V. grahamii*, HY = hybrids. Total individuals sampled are as follows (number of reproductive individuals): Site A: VH(AT1)=24(12); HY(AT2)=151(76); HY(AT3)=232(134); VG(AT4)=146(77). Site B VG=35(19); HY=95(55); VH =142 (33).

TABLE 2. Means and SE for selected ecological parameters among *V. hookeriana* (VH), *V. grahamii* (VG) and hybrids (HY). Superscript letters indicate a significant difference for a particular parameter among the taxa. Moisture and light are expressed as percents. P, N and K values are along a scale of 1 to 7 (1 = very low, 7 = high).

Taxon	Moisture	Light	pH	P	N	K
VH	26(±0.1)	16(±0.4)[a]	6.40(±0.14)	5.32(±0.49)[a]	1.28(±0.10)	6.44(±0.16)
VG	24(±1.1)	29(±0.3)[b]	6.51(±0.12)	3.82(±0.37)[b]	1.14(±0.09)	7.0(±0.13)[b]
HY	25(±0.1)	29(±0.3)	6.43(±0.10)	4.40(±0.33)	1.18(±0.08)	6.81(±0.12)

Genetic Data

A total of 242 *Viola* individuals were examined genetically with ISSRs: 33 *Viola hookeriana* in Site A and 19 in Site B, 65 *V. grahamii* individuals in Site A and 35 in Site B, and 48 putative hybrid individuals in Site A and 42 in Site B. In Site A, 70 ISSR fragments were resolved vs. 53 in Site B. The majority of these were identical between the two sites, resulting in a total of 75 unique and scorable fragments for the study sites together. The relative frequency of individual fragments ranged from less than 10% of individuals (rare to infrequent) to 100% (ubiquitous). Distribution of fragments across taxa (Table 3) showed that some were specific to one of the parental taxa (e.g., five fragments were species-specific for *V. grahamii*, and three were specific for *V. hookeriana*) whereas others were shared among taxa. Most of the shared fragments occurred between *V. grahamii* and the putative hybrids (e.g., 17 fragments in Site B). Nine fragments were specific to the putative hybrids.

UPGMA cluster analysis (Fig. 5) showed strong separation of the two study sites. All individuals diverged substantially between Site A and Site B, regardless of taxon. The PCoA confirmed these discrete site differences (Fig. 6A). Additional PCoA analyses were carried out separately on the two sites [Site A (Fig. 6B) and Site B (Fig. 6C)]. In both sites, *V. grahamii* and the putative hybrids showed the most extensive genetic overlap. In Site A, *V. hookeriana* mostly segregated from the other taxa, although some individuals clustered with putative hybrid derivatives, and others with *V. grahamii*. In Site B (Fig. 6C) two distinct groups of *V. hookeriana* were evident, with some putative hybrids occurring within each of them. In all cases, putative hybrid individuals were widely placed and substantially overlapping in distribution with the parental taxa, together expressing a greater level of genetic diversity.

The AMOVA (Table 4) showed that most of the variation was within morphologically defined taxa (69%), although significant differences were detected between sites and among taxa. Variation between sites accounted for 27% of the total variance. Differences among parental taxa and hybrids accounted for only 3.72% of the variance. The same pattern was observed when the two sites were analyzed separately. In Site A, 94.5% of the variance was due to variation within the taxa; 95.3% in Site B. If the hybrids were eliminated, variation was slightly reduced within taxa (90.32% and 89.17%); however, levels of variation within the species themselves remained high.

DISCUSSION

Our results show conclusively that hybridization is occurring between *V. grahamii* and *V. hookeriana*. Phenetic analysis of leaf shape characters in the species, more exploratory than exhaustive, showed separation among *V. hookeriana*, *V. grahamii* and the hybrids. Hybrid individuals formed a distinct group from the parental taxa suggesting that leaf

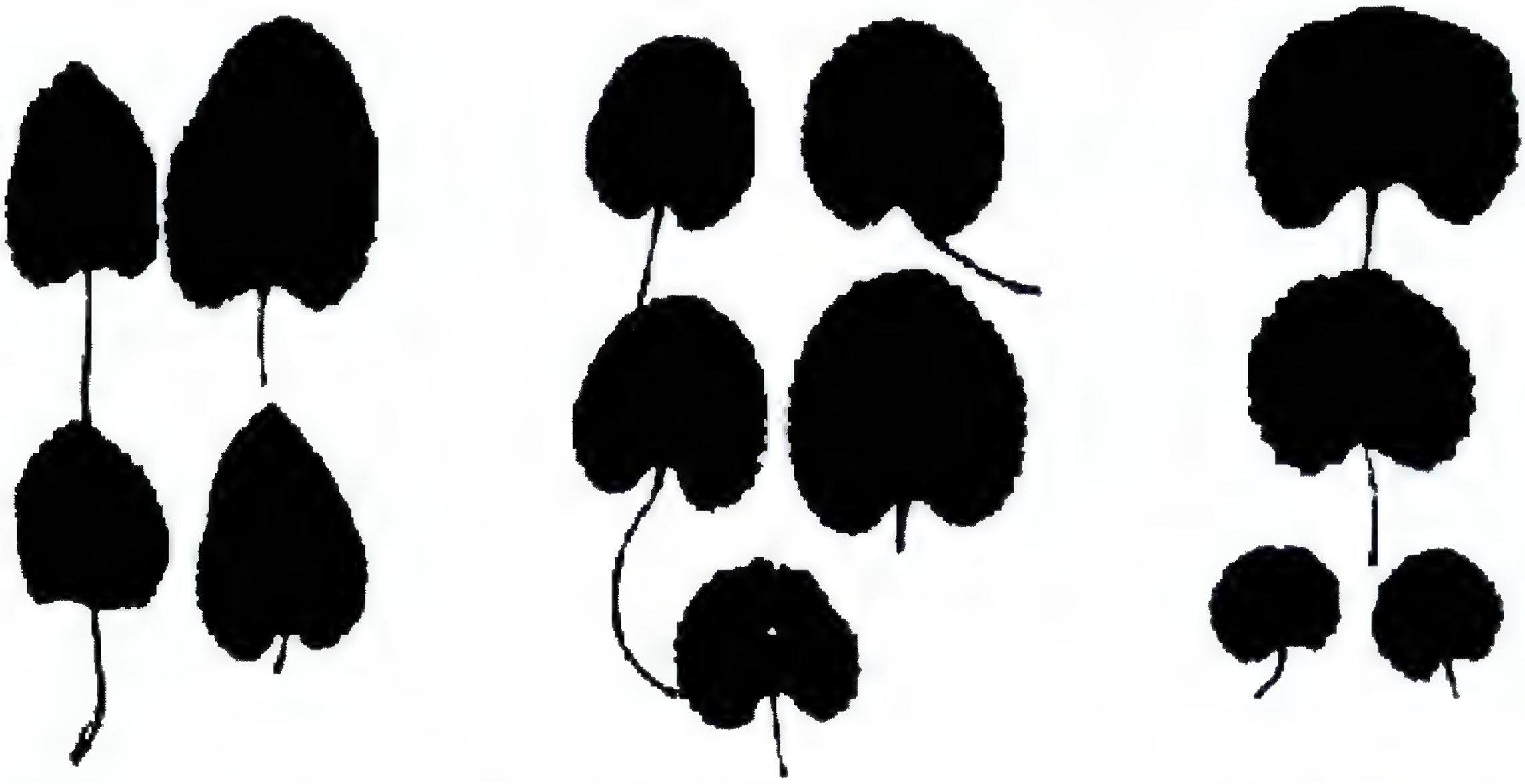


FIG. 3. Representative leaves of *Viola grahamii V. grahamii* μ *hookeriana*, and *V. hookeriana*.

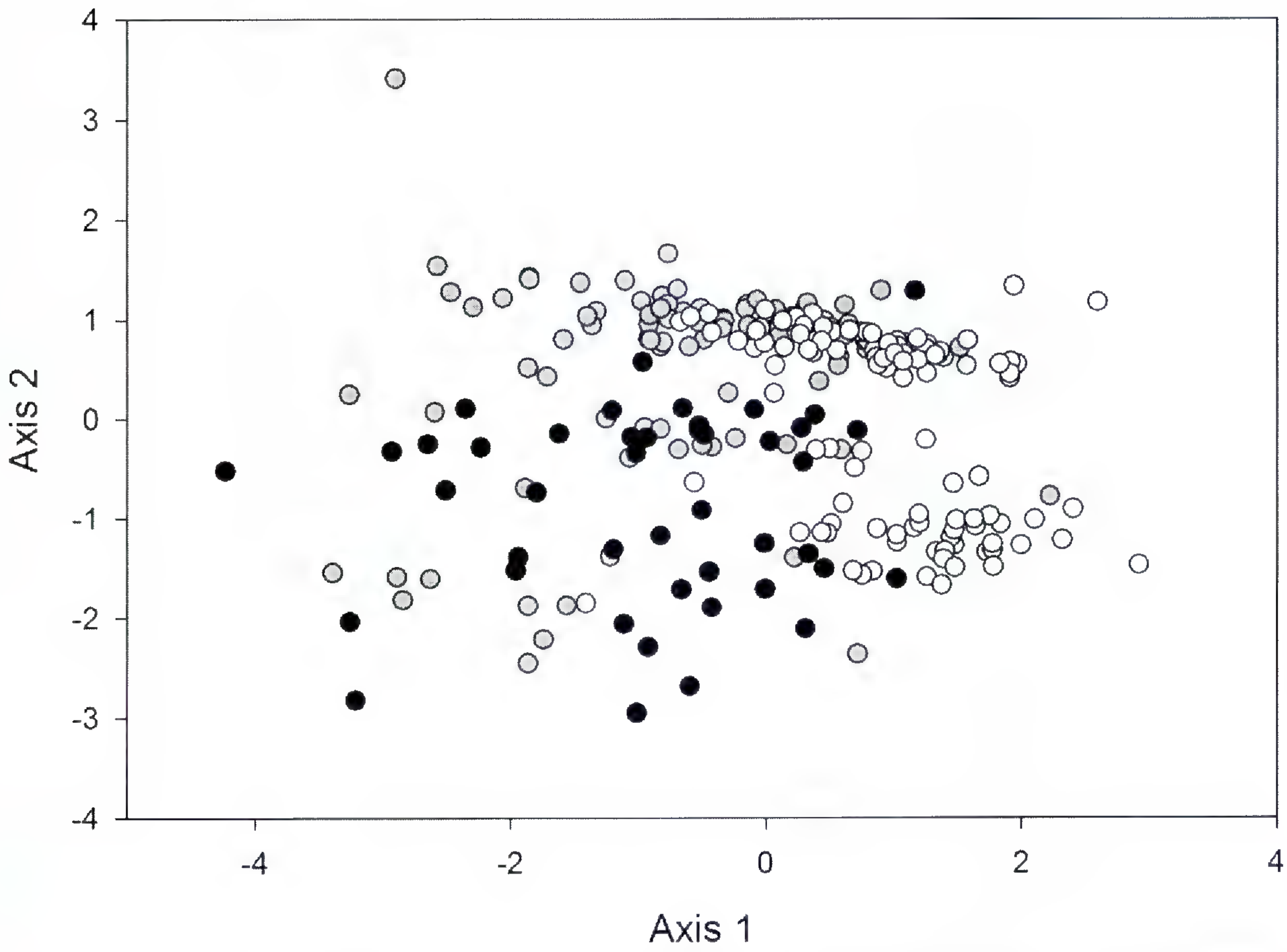


FIG. 4. Results of discriminant analysis of leaf shape from individuals of *Viola grahamii* (white dots), *V. hookeriana* (black dots) and *V. grahamii* × *hookeriana* (gray dots).

TABLE 3. Number of ISSR bands found per site per taxon (*V. hookeriana*, *V. grahamii* and hybrids), as well as number of bands shared among the taxa.

Number of bands	SITE A	SITE B
Viola hookeriana	3	1
Viola grahamii	5	5
hybrids	3	9
V. hookeriana and nybrids	1	2
V. grahamii and hybrids	11	17
All individuals	46	20

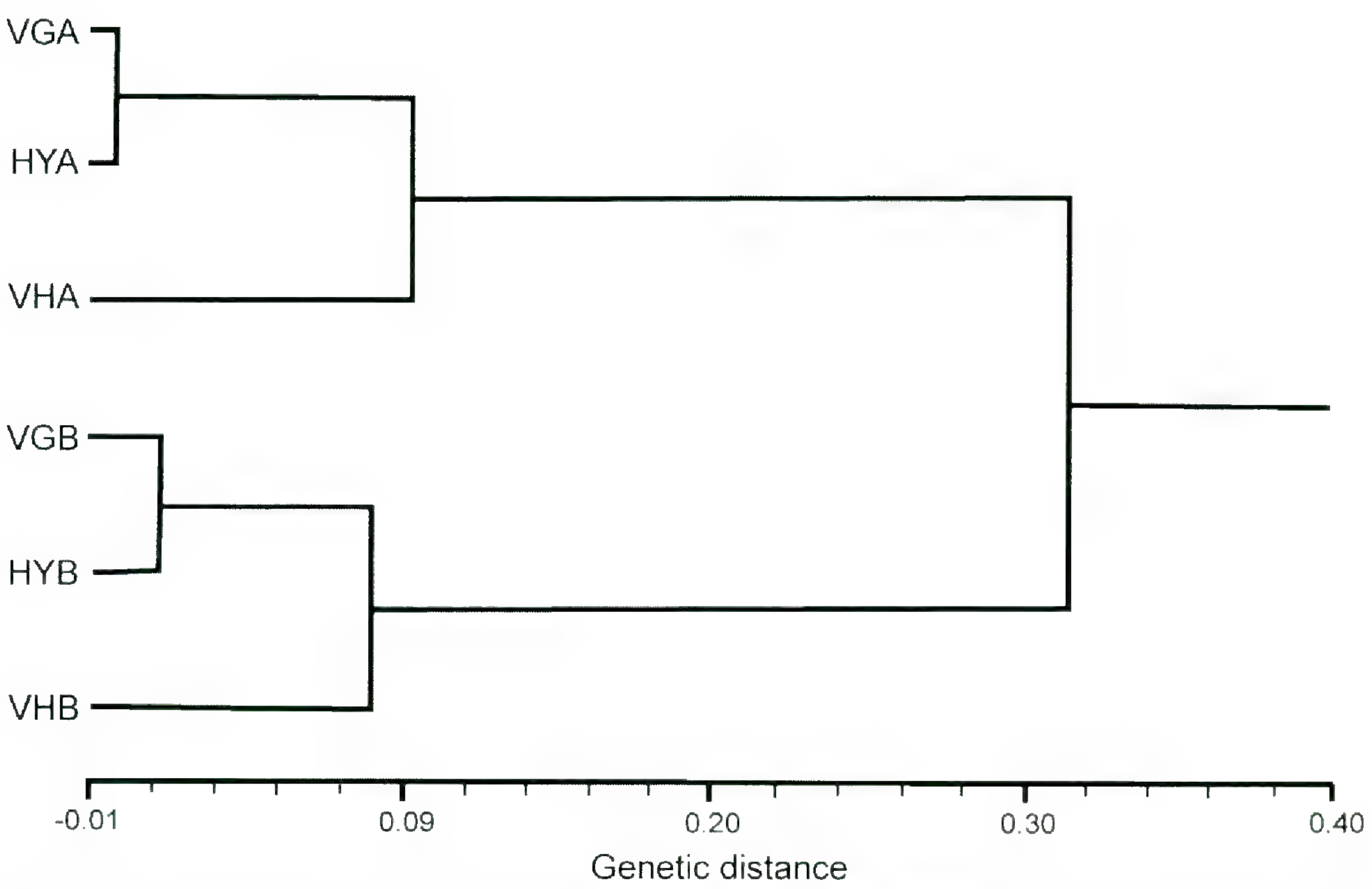


FIG. 5. UPGMA dendrogram depicting relationships among taxa and transects. Similarity compared using the AMOVA-derived PhiST distance matrix. (VHA = *Viola hookeriana* in Site A, HYA = hybrids in Site A, VGA = *V. grahamii* in Site A; the same format for Site B).

traits are useful in distinguishing the hybrids from the pure species, similar to the findings seen in other *Viola* (Russell 1954; Jonsell et al. 2000). While these differences appear to follow a clear pattern, our potential discovery of introgressant individuals may actually blur the distinction to some degree. Extensive gene flow was confirmed, and has proceeded to the extent that the two sites harbored substantially different genotypic combinations. At both sites, numerous morphologically "pure" parental individuals of the two species were demonstrated to be cryptic hybrid derivatives, with a preponderance of these resembling *V. grahamii*. High levels of genetic variability within taxa may be the product of long-continued gene flow. The results from AMOVA suggest that around 95% of the genetic variation is due to variability within each taxon. While this high level of variation could be partly artifactual, owing to rapid evolution of ISSR primer sites, it is

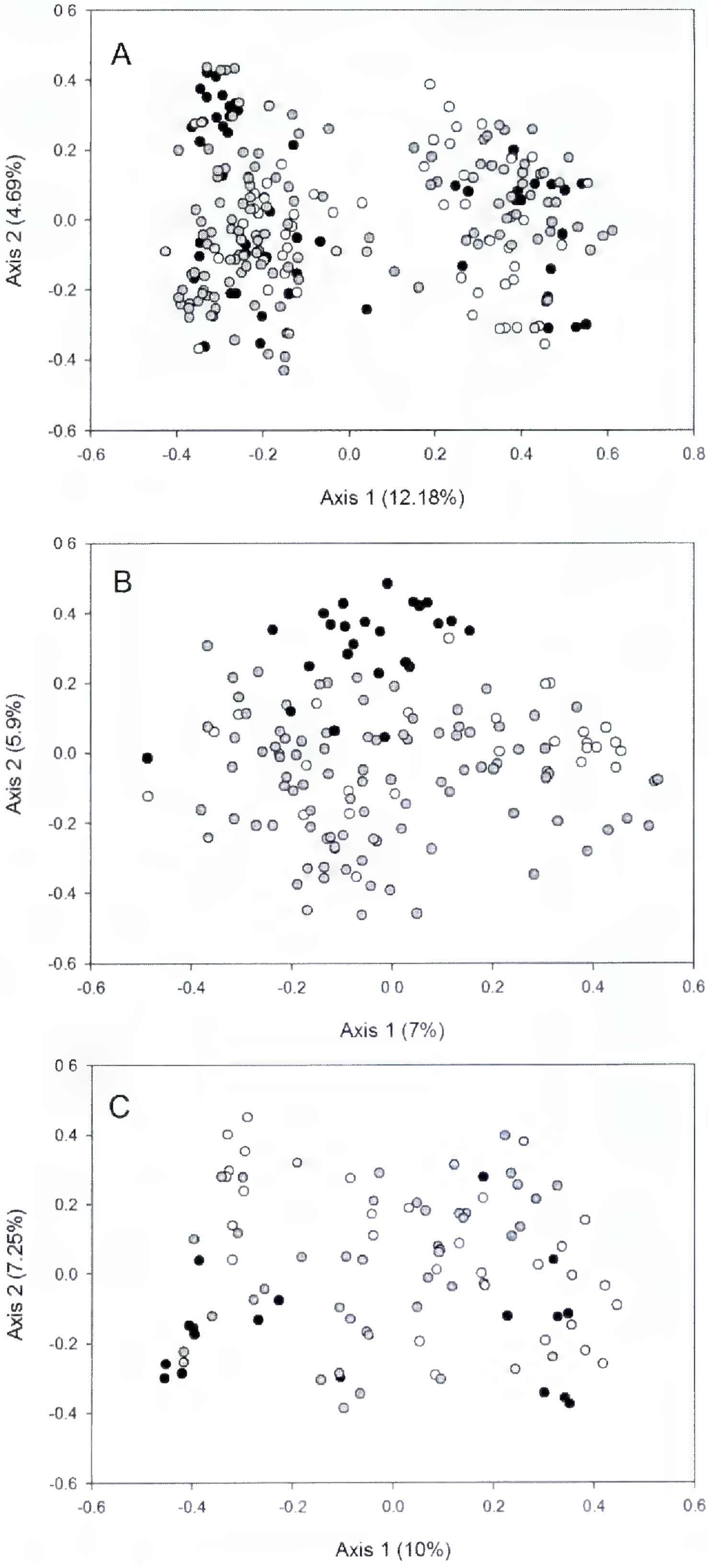


FIG. 6. **A)** Principal Coordinate Analysis (PCoA) of genetic data using the Jaccard similarity coefficient for individuals collected in both sites (A and B). **B)** PCoA of individuals collected in Site A. **C)** PCoA of individuals collected in Site B. Percentages on each axis indicate percentage of total variation explained by that axis. *Viola grahamii* (white dots), *V. hookeriana* (black dots) and *V. grahamii* × *hookeriana* (gray dots).

TABLE 4. Analysis of Molecular Variance (AMOVA) of 242 individuals collected from both sites (A and B), based on 2000 permutations. Mean squares (MDS), variance component and percentage of variance as well as P values are presented. A nested design was performed.

Source of variation	df	MDS	Variance component	Percentage	*p*
Between sites	1	286.41	2.30	26.79	< 0.0005
Among taxa	4	18.38	0.32	3.72	< 0.0005
Within taxa	236	5.98	5.98	69.49	< 0.0005
	241				

more likely that hybridization and subsequent gene flow have proceeded to the point that many morphologically "pure" parental individuals are actually products of extensive gene flow, bridging the gap between parents and hybrids and obscuring taxon boundaries.

Additional genetic evidence suggesting that the hybridization between *V. grahamii* and *V. hookeriana* has likely been occurring over a long period of time is the presence of ISSR fragments unique to the hybrids. It has been suggested by various authors that later-generation backcrosses might contain only a small number of the fragments from the parental species (O'Hanlon et al. 1999). If this is the case, the development of fragments that are "specific" to the hybrids are best interpreted as the result of later generation recombination and long-term post-hybridization genetic reorganization, as suggested by O'Hanlon et al. (1999). Studies of introgression in German violets conducted by Neuffer et al. (1999) using RAPDs describe a similar phenomenon in the *V. riviniana* Rchb.—*V. reichenbachiana* Jord. ex Bor. complex, but the fact that no unique hybrid bands were found led them to conclude that the hybrid complex had a recent origin. Directional backcrossing has also been suggested towards *V. lutea* subsp. *sudetica* (Willd.) Nyman in hybrids of this species and *V. tricolor* L (Krahulcová et al. 1996). In this study, the presence of many "hybrid-specific" bands suggested a significant time component in the formation of hybrid derivatives as well as differentiation in some. Our results suggest that introgression is occurring between *V. grahamii* and *V. hookeriana*, and that hybridization might have taken place thousands of years in the past or may occur only rarely, but high levels of interfertility and appropriate site conditions have allowed the hybrids sufficient time to backcross with the parental taxa.

Hybridization has likely been favored by the absence of a temporal reproductive isolation between the two species. Despite a minor, non significant, shift in blooming times of the two species (between populations) they have greatly overlapping blooming times, which provide extended opportunities for inter-taxon crossing. This small shift in blooming may be related to differences in microsite characteristics and levels of human perturbation such as wood cutting for local uses, which were more pronounced in Site B than in Site A. The differences in canopy openness between the two sites due to human disturbance can also explain why *V. hookeriana* was not common in Site B, while *V. grahamii* was very abundant. Open environments with more light favor *V. grahamii*, which grows best in open-canopy forest or open sites while *V. hookeriana* is most abundant in more shaded environments, mainly under the forest canopy. Other differences were found in terms of soil requirements; *V. hookeriana* grows in higher concentrations of P and lower concentrations of K than does *V. grahamii*. Soil nutrients in the area however are highly heterogenous (Cortés-Palomec 2005), and while they may be affecting the distribution

of *V. hookeriana* and *V. grahamii*, the hybrids appear to survive in various soil conditions, accounting for their wider local distribution in each site, especially in areas with moderate to heavy levels of disturbance. It is commonly suggested that since hybrid individuals have partial genotypes from both parental species they can potentially grow in both parental habitats as well as in their own "intermediate" niche and even lead to the extinction of the parental taxa if one of them is rare (O'Hanlon et al. 1999; Levin et al. 1996). In fact, hybrids between *V. tricolor* and *V. lutea* subsp. *sudetica* have been suggested to have a wider range of distribution than both parental species (Krahaulcová et al. 1996). In addition, disturbance can lead to "hybridization of the habitat" (Anderson 1954; Rieseberg & Ellstrand 1993), resulting in a mosaic of microhabitat conditions that favor hybrids and in extreme cases may cause the local extinction of one or both of the parental taxa (Rieseberg & Ellstrand 1993; Rhyme & Simberloff 1996). Hybrids in this case can be compared to alien plants in the sense that they are new elements in the flora that can threaten the original flora of the region (Neufer et al. 1999). Perturbation was high in both study sites, mainly due to human activity (i.e., livestock grazing and timber harvest). If we consider our sampling of the study sites as representative for the region, then the hybrids may be said to be as abundant or even more abundant locally in the zone of sympatry than the parental taxa. The heavy genetic overlap of hybrids with *V. grahamii* may threaten that species with local genetic swamping, but since it is widely distributed and occurs as pure populations across large regions of Mexico and northern Guatemala that is probably not a problem. Given the large number of hybrid individuals between the two species at the sites, and the comparatively small number of *V. hookeriana* plants at any given site, however, the latter species may indeed become imperiled (Levin et al. 1996).

Sharing of similar flowering times has likely favored pollen movement between the two species, however pollinator activity would play a key role in successfully moving the pollen. During the year this study took place, several potential pollinators were seen in the area of study, however none of them were observed visiting *Viola*, a finding which seems to be abnormal. Similar observations on blooming individuals of one of the species (*V. grahamii*) over the next two subsequent summers did however reveal the presence of the golden banded skipper (*Autochton cellus* Boisduval and Le Conte, Hesperiidae) and an undescribed species of bee of the genus *Dianthidium* (*Adanthidium*) in the Megachilidae (Griswold, T. pers. com.). The skipper does not seem to be very specific and visits several species showing white flowers (Cortés-Palomec 2005), but the bee does appear to only frequent *Viola* and it could be favoring gene flow between these two species. More specific studies of the pollinators would be needed to better understand their behavior.

In conclusion, we have shown that hybridization occurs between *Viola grahamii* and *V. hookeriana*, and that the hybrids are morphologically distinct and intergrading from the parental taxa. Genetically, despite a larger similarity to *V. grahamii*, the hybrids have unique alleles. Ecologically, hybrids have a wider distribution and environmental tolerance than any of the parental taxa, and at least in the area of study they are much more abundant than *V. hookeriana*. Similar flowering phenologies and effective pollen movement between the species has likely favored hybridization over a long period of time between the two species.

ACKNOWLEDGMENTS

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Book Reviews

David Fross and Dieter Wilken. 2006. **Ceanothus.** (ISBN 0-88192-762-7, 978-0-88192-762-7, hbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax.). $39.95, 272 pp., color photos, b/w illustrations, 7" × 9".

As noted on the jacket: "*Ceanothus*, with so many plants that tolerate sun and shade, that thrive in arid conditions and thus conserve water, that bear a profusion of beautiful, fragrant flowers, deserves a book that will bring more of them into gardens and encourage greater appreciation of them in the wild, and this is that book." Plenty of color photos of these spectacular shrubs and small trees. Statements of the geographic ranges are given; the only thing I can think of in improvement of this book, "The Compleat *Ceanothus*," would have been generalized range maps. The text is divided into two substantial and readable sections (chapters in parenthesis):

Ceanothus in the Garden and Landscape
(Natural Distribution; History of Cultivation; Growing *Ceanothus*; Disease and Pests; Cultivar Development; Propagation; *Ceanothus* Species and Cultivars for the Garden and Landscape [94 pages]; and *Ceanothus* Selection Guide).
Ceanothus in the Wild (an evolutionary and taxonomic overview)
(Ecological and Geographic Distribution; Form and Function in *Ceanothus*; *Ceanothus* Species [85 pages, with keys and descriptions]; and Other *Ceanothus* names)

—Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.

David D. Stuart. 2006. **Buddlejas.** (ISBN 0-88192-688-4, 978-0-88192-688-0, hbk.). Royal Horticultural Society Plant Collector Guide. Royal Horticultural Society and Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax.). $34.95, 192 pp., color photos, 7" × 9".

A guide to the genus *Buddleja*, oriented primarily toward gardeners, with plenty of detailed information. "Buddlejas are the most accomodating and rewarding of garden plants: their acceptance of challenging soil conditions and climate extremes and their resistance to pests (including deer, hares, and rabbits) are legendary." The genus includes about 100 species — the author lists and discusses 58 species of them (noting that he is concerned only with the woody species, vs. the herbaceous perennials). A middle section provides beautiful color photos of most of the 58, along with many of the distinct cultivars of *B. davidii*. The super-hardy *B. davidii* (butterfly bush) is commonly used by breeders because of its abundant and nectar-rich flowers. "The major down side of the species is its ability to colonize inhospitable wasteland sites; the tiny winged seeds, blown far and wide, are capable of germinating wherever they settle, be it old tarmac, rubble, or a crevice high on a wall. During World War II it became known as the bombsite plant in Britain, as it was always the first plant to establish itself after an attack." The North American natives *B. marrubiifolia* and *B. utahensis* are included in the book but not *B. racemosa*, *B. scordioides*, and *B. sessiliflora*.

Chapter 1. Species
Chapter 2. Hybrids and Cultivars
Chapter 3. Care and Cultivation
Chapter 4. Propagation
Chapter 5. Wildlife Attracted to Buddlejas

—Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.

HERBIVORY OF FERAL GOATS ON ESPIRITU SANTO ISLAND, GULF OF CALIFORNIA, MEXICO

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ABSTRACT

Islands are fragile ecosystems, and are especially sensitive to introduced species, particularly large herbivores. In Mexico, there are some dramatic cases. We evaluated the influence of feral goats, as well as the natives black jackrabbit and desert woodrat on the vegetation of Espiritu Santo Island, a land-bridge island in the southern part of the Baja California Peninsula. We found that goats consumed 36 vascular plant species, three times more species than natives jackrabbits and almost seven times more than woodrats. Also, goats consume all plant organs except roots, but reiterate browsing gradually affect vegetative and reproductive plant fitness. Our results support plans for the eradication of goats to spontaneously and progressively restore of the natural vegetation structure and composition. Further, a monitoring plan is recommended.

KEY WORDS: goat herbivory, *Capra hirca* eradication, goat eradication, Baja California Islands

RESUMEN

Las islas son consideradas ecosistemas muy frágiles. Estas son sensibles a la introducción de especies exóticas, particularmente herbívoros mayores. En México existen casos dramáticos. En este trabajo se evalúa el efecto sobre la vegetación en complejo insular Espíritu Santo, Baja California Sur, México, de las cabras silvestres contra el causado por las especies nativas, la liebre negra y la rata de campo. Las cabras consumen 36 especies de plantas vasculares, tres veces más especies que las liebres y casi 7 veces más que las ratas. También, se encontró que las cabras consumen todo tipo de órganos vegetales excepto raíces, pero el ramoneo reiterado afecta tanto la aptitud vegetativa y reproductiva de los vegetales. Los resultados apoyan el plan de erradicación de las cabras con la finalidad de que espontánea y progresivamente se restaure la vegetación en estructura y composición. Adicionalmente se requiere de un plan de monitoreo.

INTRODUCTION

Extinction and extirpation of native plants and animals from islands are significantly correlated with the introduction of exotic grazing mammals. Prevention of introduction and establishment of exotics on islands is vital, so that a program of eradication or control of existing exotics is required on many islands around the world, and eradication of new introductions, as soon after detection as possible, should be a high priority for conservation agencies and natural areas administrators by means of early detection and rapid response (McChesney & Tershy 1988; Burbidge 1999; Donlan et al. 2002).

Feral domestic goats (*Capra hircus* L.) are implicated in habitat destruction and alteration of species composition in sensitive insular ecosystems around the world (Scowcroft & Hobdy 1987; Jennings 1987; Parkes 1990). In the absence of population controls, goats become the ecologically dominant species on many islands, with the result that numerous native and endemic plant species have been extirpated or are threatened with extinction (Coblentz 1978; Keegan et al. 1994). A dramatic case is Isla Guadalupe in the Pacific Ocean near the state of Baja California, Mexico. This island was devastated by

grazing goats and erosion caused by soil trampling, to the extent that some native species and entire plant communities have vanished (León de la Luz et al. 2003; Oberbauer 2006).

Espiritu Santo is a small archipelago of two major land bridge islands and several islets in the southwestern Gulf of California (Fig. 1). They are included in the Gulf of California island protection program covered by Mexican environmental laws, and administered by the Natural Protected Areas Commission (CONANP). The largest island is Isla Espiritu Santo is separated on the north by a 10 m wide channel from the second island, Isla Partida Sur. Additionally, there are the islets of La Ballena, El Gallo, La Gallina, and Los Islotes (Fig. 1).

An undetermined number of domestic goats were introduced to Isla Espiritu Santo around the middle of the 20th Century to serve as a supply of fresh meat for local fishermen. Currently, there are hundreds of feral goats on the island that are gradually destroying the vegetation, eventually leading to extinction of native species. An informal animal census by the authors in spring 2001 provided an estimate of 1,000 to 1,200 goats occupying Isla Espiritu Santo. Field observers could not be more precise because the general relief, escarpments, and steep slopes made conventional counting methods impossible.

Because these islands are narrow and rocky, runoff is very rapid after the relatively rare rains. With little percolation into the soil, water is collects in occasional drainage pools. Thus, plants on the islands seem to have more profound water stress than on the main peninsula, a condition that is reflected by poor reproductive response, including less blooming, setting of fruit, and seed production than populations of the same species on the peninsula (author, pers. obs.). These conditions critically reduce the recovery capacity of the plant community, and consequently, the dependent animal guilds.

One of the greatest challenges for administrators of protected areas is maintaining biodiversity of native species and habitat loss. In Mexico, most of the islands have been protected to keep their biodiversity. This island, which is federal property and a protected area, is being considered for a program of goat eradication by the administrators (SEMARNAT, Baja California Sur). The administrators are familiar with the catastrophic effects of grazing activity on islands around the world and in Mexico.
Based on field transects, this study compared and evaluated differential consumption of plants by feral goats and the endemic black jackrabbit (*Lepus insularis* Bryant) and desert woodrat (*Neotoma lepida* Thomas subsp. *vicina* Goldman) on Isla Espiritu Santo, comparing their impacts on the vegetation. Following goat eradication, our data could provide support for prediction of the recovery of the plant community.

METHODS

Site description

The Espiritu Santo archipelago (24°24' to 24°36' N, 110°18' to 110°27' W) is part of the state of Baja California Sur. The nearest approach to the coast of the Baja California Peninsula is barely 8 km, northwest of the port at Pichilingue. The longest axis of the archipelago (NW-SE) is 19 km; the widest reach (E-W) is about 3.5 km. The archipelago covers 110 km^2, 87 km^2 on Isla Espiritu Santo and 20 km^2 on Isla Partida. The highest point, near the midpoint of the big island is 540 m (Fig. 1).

Geologically, the archipelago is composed of sedimentary rocks of volcanic origins (sandstones and conglomerates) of the Comondu Formation. Variations in resistance to weathering lead to a rugged topography. Except in a few areas, most of the surface has



Fig. 1. Geographical location of the study area in northwestern Mexico, at the Gulf of California insular system. Isolines indicate areas over 200 m. Cross (†) indicates the highest point in the island (540 m).

very steep rocky slopes where some soil is present beneath rocks. The uplands are tablelands where goats concentrate at nights. The west side of the island is highly dissected by ravines descending from the uplands to sea level. On the shore, salt flats form behind mangrove stands and sandy pocket beaches at the end of coves. The east side of the island is largely wave-cut cliffs and pebble beaches.

Weather data are not available for the island, but an approximation, based on records from the city of La Paz, suggests annual mean rainfall <170 mm and potential evaporation of 2500 mm. Rainfall is erratic, with fall-winter-spring of 8 to 10 months without any rainfall. Occasional hurricanes in the late summer could drop up to three times the annual mean.

Vegetation is typical of the peninsular Sonoran Desert, the sarcocaulescent scrubland (Shreve & Wiggins 1964) is characterized by perennials with semi-succulent stems, including cacti and deciduous woody shrubs. According to the last inventory, 254 taxa are found (Rebman et al. 2002). Families include Compositae (28 taxa), Leguminosae (25), Euphorbiaceae (24), Graminae (20), and Cactaceae (15), these five totaling 44% of all the taxa. Some of the commonest arborescent forms physiognomically dominating the slopes are: "palo blanco" *Lysiloma candida* Brandegee, "salate" *Ficus petiolaris* HBK subsp. *palmeri* S. Wats., "cacachila" *Karwinskia humboldtiana* (Roem. & Sch.) Zucc., and "cardón" *Pachycereus pringlei* (S. Wats.) Britt. & Rose.

Constant and strong winds noticeably contribute to lignosity in branches and a more

dwarf like appearance than examples of the same species growing on the Baja California Peninsula. With a north-south mountain ridge axis, the canyons run east and west, and the isolation generates different exposure-based plant associations on north-facing (shadow-side) and south-facing (sun-side) slopes. North-facing slopes having significantly more canopy and plant density than the intensely exposed south-facing slopes. Surveys by the author, based on 400 m^2 sampling plots, provide plant canopies averaging 220 m^2 on south-facing slopes and 305 m^2 on north-facing slopes, on opposite sides of the same ravine (author, unpublished data).

Sampling

In March 2001, ten straight-line transects of approximately 3 km each, were designed so that each would traverse several environments. Transects included beaches and mangrove (one site), arroyos and washes (three sites), slopes (four sites), and tablelands (two sites). Information recorded included: 1) plant and organs consumed or injured, 2) evidence for the responsible herbivorous species, based on characteristics of common sense, including type of bite on the plant and supporting evidence of droppings (pellets) beside the damaged plants. Droppings of goats are barrel form, approx. 1 cm long; those of jackrabbits are elliptic-lenticular form, approx. 1 cm long, and those of desert woodrats are linear, approx. 1 cm long.

Because the three herbivores typically defecate next to the browsed plant during feeding, we considered such occurrences related and definitive. Figure 2 shows a foraged plant and pellets of goats and black jackrabbits. Intensity of feeding activity was determined by the number of old scars on plants and the abundance and age of pellets around these plants.

RESULTS

Table 1 assembles the information by sampled sectors, showing elevation, browsed species, consumed or injured plant organs, evidence of the herbivore species, and intensity of consumption based on scat abundance. From the transect surveys, we found that browsing by goats was concentrated on the more elevated mountains of the island near La Ballena and Los Candeleros Coves, and on uplands above 400 m.

Discussion

In general terms, abundance and distribution of plants on the island is definitely dependent on terrain conditions, such as slope angle and exposure, as well as soil quality (soil deep and rockiness). These factors contribute to vegetation heterogeneity on the landscape. We believe that many native plant species have been modified by goat browsing over the past several decades, knowing that goat herbivory directly affects fitness and reproductive success of mature plants and also contributes to consumption of juvenile plants. Donlan et al. (2002) documented positively changes in plant coverage on several Gulf of California islands after extirpation of exotic herbivores.

Some actively browsed plant species are the perennial herbs *Bebbia juncea* (Benth.) Greene, *Justicia californica* (Benth.) Gibson, and *Ditaxis lanceolata* (Benth.) Pax & K. Hoffm. and the sub-shrubby *Aeschynomene nivea* Brandegee. We found that browsing of terminal branches promotes sprouting from basal nodes, leading to a branching architecture of unusually short basal trunks and numerous branches. Several individual "palo blanco" *Lysiloma candida*, one of the few tree-like species, had trunks stripped of the high-tannin bark, as well as shrubby species of "lomboi" *Jatropha cinerea* (Ortega) Muell.-Arg.



FIG. 2. Clades of *Opuntia tapona* showing damage. Note goat and jackrabbit pellets on ground.

TABLE 1. Perennial plant species affected by herbivory of feral goats, black jack-rabbits (BJR), and wood rats on Isla Espiritu Santo, Baja California Sur, Mexico, based in ten 3-km transects during a field survey in spring 2001.

Plant species (asl)	Consumed organ	Herbivore	Intensity
Beaches and mangrove (0–2 m)			
Rhizophora mangle L.	Leaves, Bark	Goat	Low
Avicenia germinans (L.) L.	Leaves, Bark	Goat	Low
Monantochloe littoralis Engelm.	Leaves	BJR	Low
Jouvea pilosa (Presl.) Scribn.	Leaves	Goat	Low
Arroyos and washes (5–15 m)			
Viscainoa geniculata (Kell.) Greene	Leaves	Goat	Low
Forchammeria watsonii Rose	Leaves	Goat	Low
Euphorbia magdalenae (Benth.) Millsp.	Buds	Goat	Low
Lysiloma candida Brandegee	Flowers, Leaves, Bark	Goat	Low
Melochia tomentosa L.	Buds	Goat	Low
Stenocereus gummosus (Engelm.) Gibson & Horak	Stems	BJR, Rat	Low
Pachycereus pringlei (S. Wats.) Britt. & Rose	Flower, Bark	Goat, BJR	Low
Simmondsia chinensis (Link) Sch.	Leaves	Goat	Low
Colubrina viridis M. E. Jones	Bark	Goat	Low
Bebbia juncea (Benth.) Greene	Leaves	Goat	Low
Cochemia poselgeri (Hildmann) Britt. & Rose	Stems	BJR, Rat	High
Prosopis articulata S. Wats.	Stems, Leaves	Goat, BJR	Medium
Slopes (10–150 m)			
Justicia californica (Benth.) Gibson	Stems, Leaves, Buds	Goat	High
Ditaxis lanceolata (Benth.) Pax & K. Hoffm.	Stems, Leaves	Goat	High
Desmanthus fruticosus Rose	Stems, Leaves	Goat	High
Aeschynomene nivea Brandegee	Stems, Leaves	Goat	High
Agave sobria Brandegee var. *roseana* (Trel.) Gentry	Flowers	Goat	High
Acacia pacensis Rudd & Carter	Buds	Goat	High
Heteropogon contortus (L.) Beauv. ex Roem.	Leaves	Goat	Medium
Cylindropuntia cholla Weber	Flowers, Fruit	BJR, Rat	Low
Macrosiphonia hesperia I. M. Jhtn.	Stems, Leaves	Goat	High
Ficus petiolaris subsp. *palmeri* S. Wats.	Leaves, Buds	Goat	High
Bouteloua reflexa Swallen	Leaves	Goat	Medium
Solanum hindsianum Benth.	Buds	Goat	Medium
Tableland (150–450 m)			
Acacia pacensis Rudd & Carter	Stems	Goat, BJR	Medium
Agave sobria Brandegee var. *roseana* (Trel.) Gentry	Flowers, Leaves	Goat	Medium
Bursera epinnata (Rose) Engler	Buds	Goat	Medium
Caesalpinia placida Brandegee	Stems, Leaves	Goat	Medium
Parkinsonia florida Benth. ex A. Gray subsp. *peninsulae* (Rose) Carter	Stems, Leaves, Buds	Goat	Medium
Fouquieria burragei Rose	Buds	Goat	Medium
Jatropha cinerea (Ortega) Muell.-Arg.	Buds	Goat	Occasional
Lysiloma candida Brandegee	Bark	Goat	Medium
Olneya tesota A. Gray	Buds	Goat	Medium
Opuntia tapona Engelm.	Stems	Goat, BJR	Medium
Simmondsia chinensis (Link) Sch.	Stem, Leaves	Goat	Medium
Euphorbia magdalenae (Benth.) Millsp.	Buds	Goat	Occasional
Euphorbia tomentulosa (S. Wats.) Millsp.	Buds	Goat	Occasional
Xylothamia diffusa (Benth.) G.L. Nesom	Stems, Leaves	Goat, BJR	Occasional

TABLE 1. continued

Plant species (asl)	Consumed organ	Herbivore	Intensity
Tableland (150–450 m) (cont.)			
Stenocereus gummosus (Engelm.) Gibson & Horak	Stems	BJR	High
Maytenus phyllanthoides Benth.	Stems	BJR, Rat	Low
Pedilanthus macrocarpus Benth.	Stems	BJR	Occasional
Opuntia cholla Weber	Stems	Goat, BJR	Medium
Hyptis laniflora Benth.	Buds	Goat, BJR	Medium
Pachycereus pringlei (S. Wats.) Britt. & Rose	Stems	Goat, BJR	Occasional
Echinocereus brandegeei (Coult.) K. Schum.	Stems	Rat	Medium

(see Fig 3). Some plants of "cardón" *Pachycereus pringlei*, a large columnar-arborescent cacti, have old scars on their trunks (>20–40 cm above the ground), evidence of browsing by goats and probably also jack-rabbits during periods of severe drought. Our observations suggest that only two species of "choya" cacti (*Cylindropuntia cholla* Weber and *C. alcahes* Weber) could benefit from goat browsing because sexual reproduction in these two species is very limited and their jointed stems separate easily, adhere to goat hair, and are easily dispersed and eventually they could settling by vegetative processes.

Black jackrabbits and desert wood rats have a significantly lower impact on the vegetation because, as smaller browsers; individually they consume less plant material and their population biomass seems to be less than the hundreds of goats.

From the data assembled in Tables 1 and 2, we found that the most intense location of browsing by goats is on stems and, at least during spring, is frequent and intense. This browsing habit almost entirely consumes the floral and leaf shoots, the juicy and less woody tissues of the plants. After the rainy season, the goats concentrate on browsing the newly emerging foliage.

The evidence indicates that a set of plant species display consumption of or injury to the meristematic apex of the branches, that is, the fresh and fluid-filled tissues, rather than woody tissue and stem bark. Clades of *Opuntia tapona* Engelm. are specially consumed by all the animals because the high water content. With freshwater in very short supply and stored in "tinajas" after rainfall, goats manage to prosper by drinking salty water (Burke 1990). During our field work, we observed a few goats drinking seawater at the beach at sunset, which suggests daily or close to daily migration from the uplands to the shore. At the shore, goats also consume halophytic plants, including mangrove and species of salt grasses.

Our findings demonstrated that goats are the most significant herbivores, capable of consuming almost all plant parts. While the native black jackrabbit and desert woodrat have the same feeding habits as goats and inhabited the island for millennia, their density and biomass have far less impact on the vegetation.

Finally, there was no direct evidence that goats consume an entire plant; however, high intensity herbivory strongly affects the fitness of each grazed plant, and can eventually lead its death. We conclude that the natural balance of vegetation on Isla Espiritu Santo is deleteriously affected by goat herbivory, which combined with the impact of the native foragers, increases the deleterious effects of browsing on a large group of plant species. Our data supports plans for the total eradication of goats from the archipelago.



FIG. 3. An exemplar of *Jatropha cinerea* showing damage by goats, note bark stripping and broken branches.

TABLE 2. Concentrated data of plants consumed by herbivores on Isla Espíritu Santo, Gulf of California, Mexico.

Herbivore	Plant species consumed	Plant organs consumed	Sector of activity
Goats	36	Flowers, buds, leaves, young stems, bark	Slopes, high tablelands
Jackrabbits	13	Stems	Arroyos, high tablelands
Woodrats	5	Stems, fruit	Arroyos, slopes

On an ecological basis, black jackrabbit and woodrats are foragers that control the vegetation growth.

After eradication a monitoring plan is strongly recommended. We hope that the same plants indicated in Table 1 will increase their density and size. In fact, eradication of goats is currently underway by the administrators of the island. The project is expected to be completed by winter 2006/07, with only radio-collared and sterile sentinel goats remaining (Donlan et al. 2002).

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Book Reviews

Douglas D. Stokke and Leslie H. Groom (ed.). 2006. **Characterization of the Cellulosic Cell Wall.** (ISBN 0-8138-0439-6, 978-0-8138-0439-2, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** orders@ames.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax 1-800-862-6657, www.blackwellprofessional.com). $149.99, 274 pp., color photos, numerous b/w illustrations, 7" × 10".

"Crack" as the twig breaks, the slightly elastic wood suddenly yielding ... but so much more. This collection of studies, fundamental and applied science, represents the proceedings of a workshop cosponsored by the USDA Forest Service, the Society of Wood Science and Technology, and Iowa State University—"the result of collaboration between three institutions with a long history of research and scientific communication regarding lignocellulosic substances, primarily wood." The book is "intended for scientists, university faculty, graduate students, and applied researchers in the fields of wood science and technology, cellulose science, and biomaterials." The book is arranged in three sections:

Cell Wall Assembly and Function: New Frontiers (5 chapters, e.g.: tracheid and sclereid differentiation in callus cultures of *Pinus radiata*; mechanics of the wood cell wall; prediction of wood structural patterns by using ecological models of plants water relations)

Probing Cell Wall Structure: Advances in Analysis (6 chapters, e.g.: determining xylem cell wall properties by using model plant species; near infrared spectroscopic monitoring of the diffusion process of deuterium-labeled molecules in wood; wood stiffness by X-ray diffractometry)

Mesostructure and Applications: Science in Practice (8 chapters, e.g.: variation in kink and curl of longleaf pine fibers; wood structure and adhesive bond strength).

—Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.

Martha J. Groom, Gary K. Meffe, and C. Ronald Carroll. 2005. **Principles of Conservation Biology, Third Edition.** (ISBN 0-87893-518-5, hbk.). Sinauer Associates, Inc., 23 Plumtree Road, Sunderland, MA 01375-0407; U.S.A. (**Orders:** orders@sinauer.com, www.sinauer.com, 413-549-4300, 413-549-1118 fax). $92.95, 699 pp., 369 illustrations, 8 1/2" × 11".

This is a major update and revision of the 1997 Second Edition, with much new information and guided by a survey of "over 60 instructors on their needs for teaching conservation biology." The text is divided into three major units: *Conceptual Foundations for Conservation Biology* (5 chapters); *Focus on Primary Threats to Biodiversity* (6 chapters); *Approaches to Solving Conservation Problems* (7 chapters). A "companion website contains a variety of study materials and supplemental resources to accompany the textbook." On the first page of Chapter 1: "the cumulative impacts of 6.4 billion people (Figure 1.1) have stressed the many ecological support systems of the planet. ... All people should recognize the degree to which human impacts affect the natural world, and in turn, diminish our abilities to prosper." All biologists who think about conservation should have this book at hand (or one like it, if there's another so good).*—Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

A DEMOGRAPHIC AND ECOLOGICAL ANALYSIS OF *GEOCARPON MINIMUM* (CARYOPHYLLACEAE): A FEDERALLY THREATENED SPECIES IN SOUTHWEST MISSOURI

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ABSTRACT

A *Geocarpon minimum* population growing on a sandstone glade in Dade County, Missouri was monitored for ten years (1994–2003). Plants were counted annually in eight permanent plots at two scales (0.01 and 1.0 m^2) to determine population fluctuations through time. Soil depths as well as cover of bryophytes, lichens, vascular plants, and bare rock/soil were recorded in subplots between 1994 and 2000 to determine any possible association with *G. minimum* numbers. The number of *G. minimum* plants in the eight plots varied from 1 to 4230, with a mean of 1332. Mean soil depth of subplots containing *G. minimum* was 19 mm. There was a weak association ($r_s = 0.16$, $P < 0.001$) between soil depth and *Geocarpon* density. Regression analyses show that *G. minimum* numbers tend to increase with increasing soil depth to about 20 mm and decline thereafter. In addition, there were significant differences among vegetation types ($P < 0.05$) with the exception of lichens ($P \geq 0.05$). There was a significant difference between *G. minimum* population numbers and year ($P < 0.05$). There was discontinuity with scale and the Spearman rank correlations, however, when ecological groups were combined into larger categories (i.e., lichens and bryophytes were lumped into cryptogams), patterns were clearer across scales. Documentation of bare rock areas indicates a dynamic process of soil movement into and out of plots, but cover data did not indicate a consistent increase in coverage of moss, vascular plants, or lichens during the ten years of the study. It is concluded that *G. minimum* utilizes habitats with periodic soil disturbance and with minimal competition from bryophytes or perennial vascular plants. Although seed bank was not a subject of this study, its importance was evident from annual census data that showed the population is capable of rebounding dramatically following years with virtually no seed production.

RESUMEN

Una población de *Geocarpon minimum* fue monitoreada durante diez años (1994–2003) en un afloramiento de arenisca y suelo poco profundo en el condado de Dade en el estado de Missouri. Para determinar la fluctuación del número de plantas en la población durante el período de estudio, las plantas se contaron anualmente en ocho parcelas permanentes usando dos escalas (0.01 y 1.0 m^2). Durante los años 1994 hasta el 2000 fueron evaluados datos sobre profundidad de suelo, cobertura de briofitas, líquenes, plantas vasculares y área de tierra o rocas sin plantas en subparcelas con el propósito de determinar la posible asociación de estas variables con el numero de plantas de *G. minimum*. El número de plantas de *G. minimum* en las ocho parcelas varió de 1 a 4230 con un promedio de 1332. La profundidad promedio del suelo de las subparcelas con *G. minimum* fue de 19 mm. La asociación entre la profundidad de suelo y densidad de plantas de *Geocarpon* fue mínima ($r_s = 0.16$, $P < 0.001$). El análisis de regresión demostró que el número de *G. minimum* parece aumentar a medida que la profundidad de suelo alcanza los 20 mm y disminuye a mayor profundidad. Además, la diferencia entre tipos de vegetación ($P <$ 0.05), con excepción de los líquenes ($P >= 0.05$), fue significativa. La diferencia fue significativa también entre el número de plantas de *G. minimum* y el año del muestreo ($P < 0.05$). Se observó una discontinuidad entre escala y las correlaciones de rango de Spearman, sin embargo, al combinar los grupos ecológicos en categorías mayores (por ejemplo, los líquenes y las briofitas se unieron en la categoría de las criptógamas), los patrones fueron más claros a través de las escalas. La documentación sobre áreas de afloramiento de rocas indica la existencia de un proceso dinámico de movimiento del suelo dentro y fuera de las parcelas, pero los datos sobre cobertura no indican un crecimiento constante de cobertura de musgos, plantas vasculares o líquenes durante los diez años del estudio. La conclusión es que *G. minimum* utiliza hábitats de suelos que están cambiando constantemente y tienen poca competencia de briofitas y plantas perennes vasculares. Aunque el banco de semillas en el suelo no se investigó

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en este estudio, su importancia fue evidente. En base a los datos anuales, esta población de *G. minimum* tiene la capacidad para reproducirse considerablemente en años siguientes aunque no exista producción de semilla en años anteriores.

INTRODUCTION

Geocarpon minimum Mack. (Caryophyllaceae) is a tiny, succulent winter annual that grows on sandstone glades in Missouri, on saline soil prairies in Arkansas and Louisiana (U.S. Fish and Wildlife Service 1993; McInnis et al. 1993; Orzell & Bridges 1987), and on saline barrens in Texas (Keith et al. 2004) (Fig. 1). The diminutive height of the plant (up to 4 cm), its inconspicuous flowers, and its limited distribution are probably responsible for it not having been described until 1914 (Mackenzie 1914). Taller plants are usually multi-stemmed and many-flowered. The smallest plants are only a few mm in height and produce just one flower. Both morphologies are often present in a single population, requiring surveyors to acquire a broader search image to locate the full range of plant forms. Plants turn from a whitish-green to wine-colored to light brown as they mature and senesce.

Geocarpon minimum was designated by the U.S. Fish and Wildlife Service as a federally threatened species in 1987 because of low population numbers (U.S. Fish and Wildlife Service 1987). It is known today from fewer than 35 sites (Nienaber 2005). Twenty-four extant Missouri populations are known from Pennsylvanian-age sandstone glades in seven southwestern counties, giving it a state rank of S2 (Missouri Dept. of Conservation 2006). The sandstone glades occur in the Springfield Plain subsection of the Ozark Highlands ecological section and are considered imperiled (a rank of S2) because of their rarity within the state (Nelson 2005). *G. minimum* is considered extirpated from its type locality, Jasper County, Missouri, where suitable habitat may have been lost due to land-use changes.

Prior to this study, little was known about the management requirements for maintaining populations of *G. minimum* or the range of year-to-year population fluctuations. Several sites for the species occur on public lands where lack of information has led to a lack of management action. There was concern that some periodic disturbance might be necessary to maintain suitable microhabitat for *G. minimum*. On many of the glades where the species occurs, the thin soil near the rock/soil interface is dominated by dense mats of moss, except where trampling, off-road vehicle use, or water flow have maintained areas of loose sand. The purpose of this study was to gather long-term monitoring data that could provide needed insights for effective management of *G. minimum* populations. Specific objectives of this study were to:

1) provide a long-term census of *G. minimum* at the Flint Hills Glade site,

2) determine the correlation of bryophytes, lichens, vascular plants, and soil depth on the *G. minimum* population,

3) provide management recommendations for the conservation of this species.

MATERIALS AND METHODS

Study Site

The study site, Flint Hill Glades, is located in Dade County, Missouri, near Stockton Lake, on land owned and managed by the U.S. Army Corps of Engineers (Fig. 2). *Geocarpon minimum* was discovered at Flint Hill Glades during a 1989 survey for the species (Thurman & Hickey 1989). The site is atypical in one respect; the impoundment of Stockton Lake inundated the creek valley below the glade and floods the lower portions of the glade during extremely high lake levels, which occurred during the summer of 1993.



FIG. 1. *Geocarpon minimum* plant. Photo by Rick Thom

It is estimated that less than five-percent of the six-acre glade area is suitable habitat for *G. minimum*, which grows in greatest abundance in shallow sand- and pebble-filled depressions in the sandstone bedrock that are often devoid of other plants (Fig. 3). Based on research at another Dade County site, Morgan (1986) reported that optimum habitat was found in zones of shallow soils (1–5 cm) over sandstone bedrock. These microhabitats are maintained by flow of water over the bedrock that deposits sand and pebbles into the depressions. Water flow can also carry away previous deposition and prevent lichen or vascular plant succession. An intermittent drainage flows through the study site carrying runoff from adjacent grazed pasture on private property into Stockton Lake at the lower edge of the glade.

Much of the surface bedrock is covered by a thick mat of mosses (principally *Polytrichum ohiense* Ren. & Card.) intermixed with lichens, liverworts, and a few vascular plant species. Areas of deeper soil within the glade support grasses, shrubs (e.g. *Vaccinium arboreum* Marshall) and dwarfed trees (e.g. *Quercus marilandica* Muenchh. and *Amelanchier arborea* (F. Michx.) Fernald). *Geocarpon minimum* plants were observed in the grazed portion of the glade on adjacent private land during the course of this study. They are found only near a bedrock exposure where pasture grasses are not established. The dense beds of moss found on the study site are not present in the pasture. The trampling from cattle may help to maintain the loose sand particles that accumulate to form *G. minimum* microhabitats. The pasture area may be a source of *G. minimum* seed for the monitoring area. No monitoring plots were established in the pasture, primarily because cattle grazing is not viewed as a realistic management tool for most publicly-owned sites.

Data Collection

Ten plots were established at the site in April 1994. The 1.0 m × 1.0 m quadrats were sub-

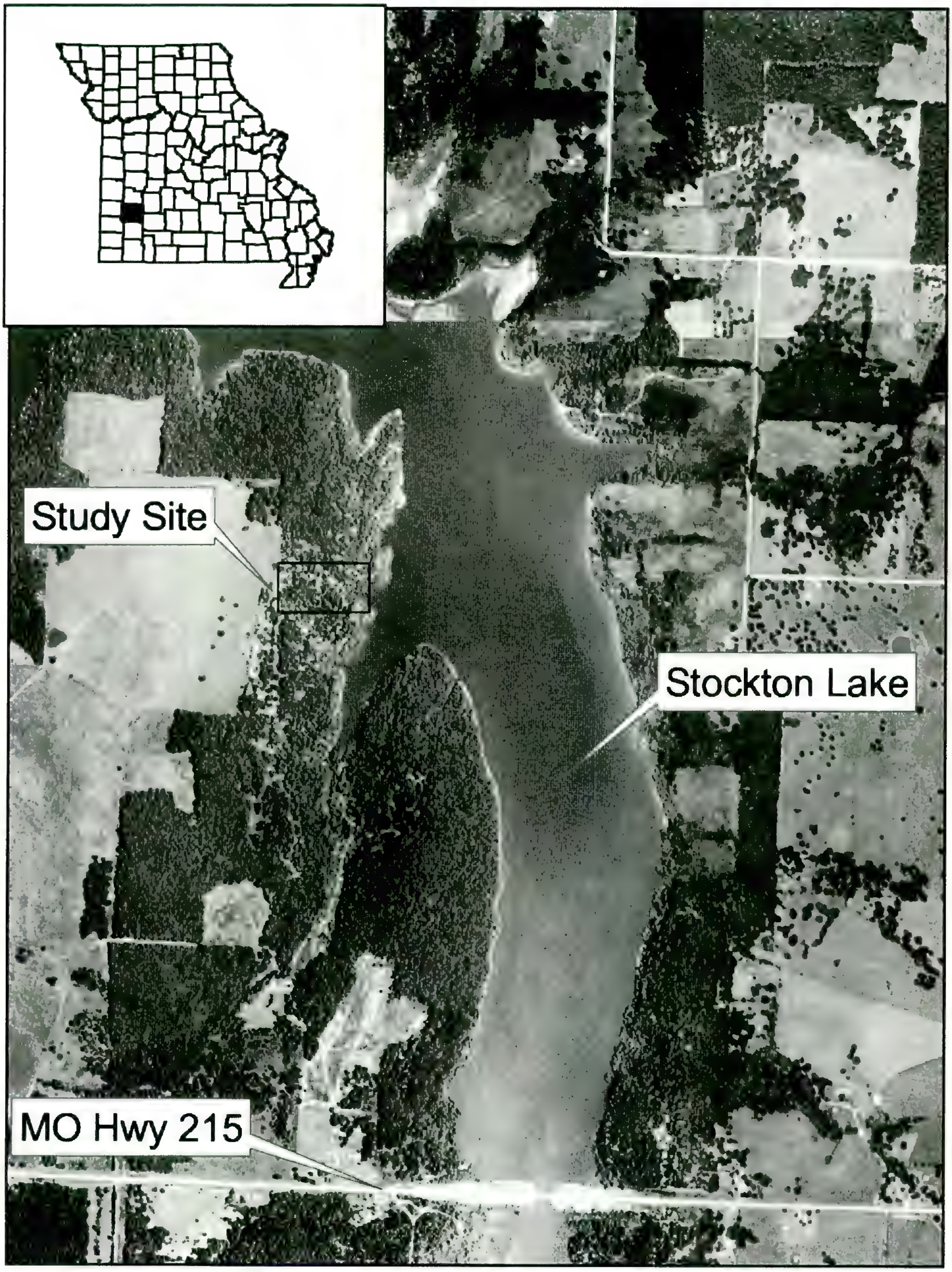


Fig. 2. Aerial photograph of Flint Hill Glade system, Stockton Lake, Dade County, Missouri.

jectively located in areas containing *G. minimum* in close proximity to areas dominated by mosses, lichens, or perennial vascular plants. Two opposite corners of each plot were marked by masonry nails driven into holes that were drilled into the bedrock.

Two of the original ten plots eventually were dropped from the study because they



FIG. 3. Habitat at Flint Hill Glades. Photo by Tim Smith.

did not support any *G. minimum* after 1994. Inundation of part of the glade in 1993 created temporary habitat in these plots due to silt and sand deposition with little vegetative competition. At one plot, sand and silt was deposited into a patch of bryophytes on bedrock, temporarily providing habitat that supported *G. minimum*. The bryophytes had been killed by the prolonged inundation and were soon gone, leaving only bare rock at subsequent surveys. The other plot was located near the lake shore and included essentially bare sand after the inundation, although it had deep enough soils to support perennial vascular plants. Although *G. minimum* was found in the plot when it was established in 1994, this plot thereafter became covered with debris from subsequent rises in the lake level and no longer contained exposed sand or *G. minimum*.

A 1 m × 1 m (1.0 m^2) wooden frame was used to monitor the permanent plots. Fly-fishing line was strung on the inside of the quadrat to further subdivide the 1.0 m^2 plots into 100 subplots of 10 cm × 10 cm (0.01 m^2). The number of *G. minimum* plants was recorded in each subplot. Soil depth was measured at the center of each subplot by using a nail to probe to bedrock and then measuring the length of the nail that had entered the soil. Bare rock was recorded as zero soil depth. Vegetative cover was estimated using seven cover classes (a modified Daubenmire cover class) and dominant cover was characterized as mosses, lichens, vascular plants or bare rock/soil (Daubenmire 1959) The seven cover classes were: 1 (0–1%), 2 (1–5%), 3 (5–25%), 4 (25–50%), 5 (50–75%), 6 (75–95%) and 7 (95–100%).

In the spring of 1995, three additional plots were established within the study area, in moss-dominated areas that did not contain *G. minimum*. These plots were created by removing a 1 m × 1 m section of dense moss to expose underlying mineral soil or bed-

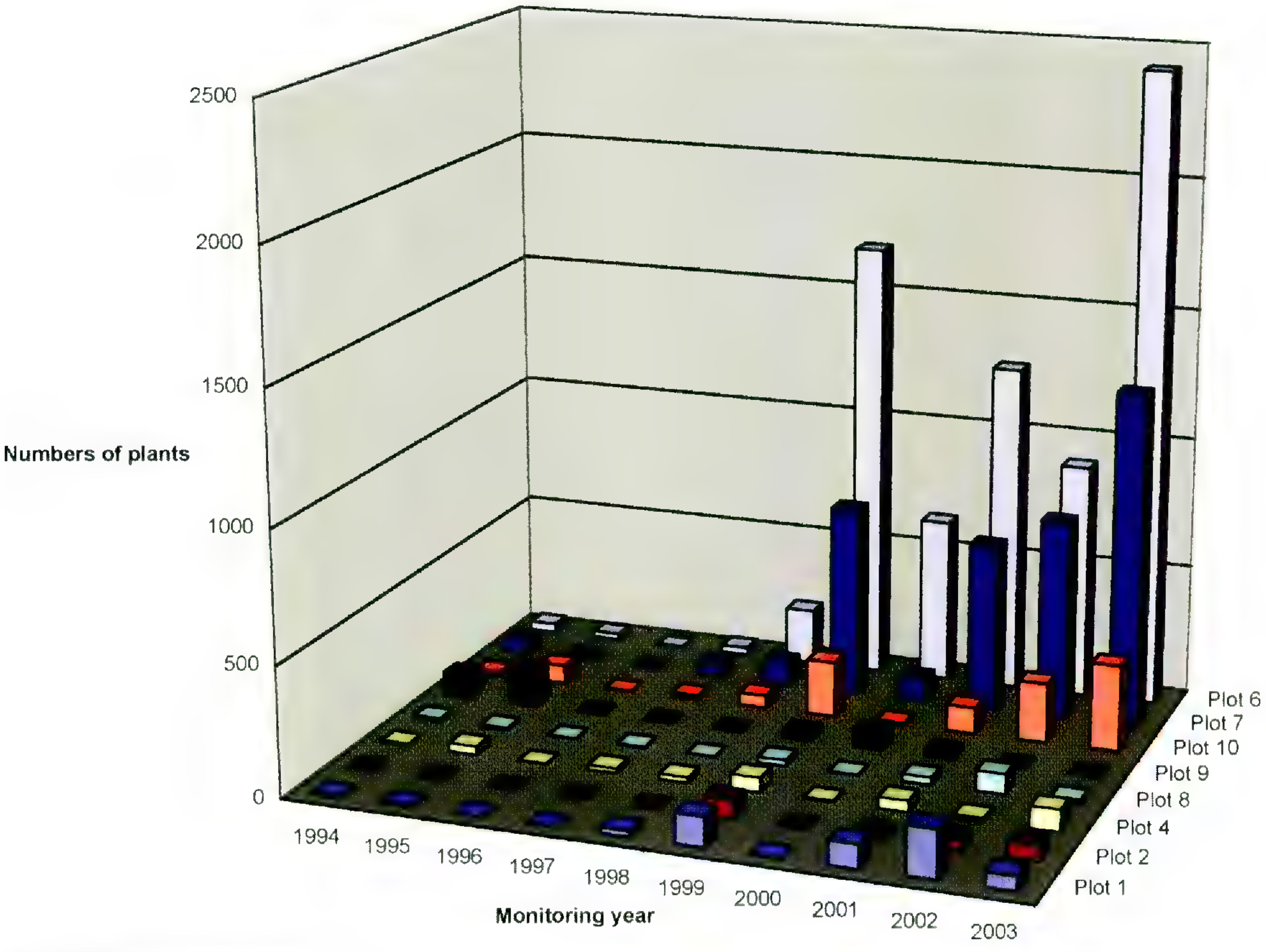


FIG. 4. Numbers of *Geocarpon minimum* plants in permanent plots from 1994 to 2003.

rock. These three plots were subsequently monitored for *G. minimum*, but soil and cover measurements were not taken.

Data Analysis

The subplot (0.01 m^2) values of *G. minimum* numbers, soil depth, and cover classes for each vegetation type (see above) were summed within each large plot (i.e., 1.0 m^2) and were subsequently used for all analyses (Spearman rank correlation, analysis of variance, and regression analyses). The independent variables were year, soil depth (mm), and cover values of bryophytes, lichens, and vascular plants. Lichens and bryophytes were combined into a single category (cryptogams) and vascular plants and cryptograms were also combined into a single category of total vegetation.

Spearman rank correlation coefficients, r_s, (Zar 1999; Sokal & Rohlf 1995) were calculated on both subplots and large plots in order to determine strength of association among *G. minimum*, year, soil depth, bryophytes, lichens, cryptogams, vascular plants, and total vegetation at two spatial scales (0.01 m^2 and 1.0 m^2). In addition, partial correlations were also determined on ranked data controlling for the effect of year to determine potential associations among the vegetation types and soil.

Model II regression analyses were performed with the number of subplots that contain *G. minimum* as the dependent variable and soil depth as the independent variable. The regression analyses were performed on subplots only. Note that both soil depth and the number of subplots that contain *G. minimum* follow a normal distribution, as indi-

cated by a Kolmogorov-Smirnov normality test ($P > 0.05$). Specific regression analyses were performed independently on soil depth range of 1 to 20 mm and 21 to 110 mm. The justification for the latter was to show that the subplots containing *G. minimum* increase with increasing soil depth to 20 mm and declines thereafter.

A Friedman repeated measures (FRM) analysis of variance (ANOVA) (a non-parametric equivalent to the parametric repeated measures ANOVA) was used to determine differences among population numbers annually. Natural log transformed *G. minimum* numbers was the dependent variable, year was the repeated measures factor, and plot was the subject factor (Zar 1999; Sokal & Rohlf 1995). Because some of the plots had zeros and ones, it was necessary to add a count of 2 (a constant) to each observation for natural log (ln) transformation (Zar 1999; Sokal & Rohlf 1995). The transformation was done in order to improve statistical models (Quinn & Keough 2002) and to maximally normalize the data. Independent variables, with the exception of year and plot, were treated as random in all models because they were not specifically controlled (Zar 1999; Sokal & Rohlf 1995). The year 1996 was excluded from all analyses because only one *G. minimum* plant was observed for that year and thus it was considered as an outlier.

Additional FRM ANOVAs were performed on cover classes of bryophytes, lichens, vascular plants, cryptogams, total vegetation, and soil depth. There were three cover classes for bryophytes, lichens, vascular plants, cryptogams, and total vegetation while soil depth was placed into six. FRM ANOVA was performed on the large plots only. Independent variables were natural log transformed as needed. Additional repeated measure ANOVAs (Kruskal-Wallis) were performed without 1999 data in order to ascertain the relationship between soil depth and vegetation groups without the possibility of an interacting effect or confounding influence for the year 1999. The year 1999 was considered an outlier similarly to 1996 but with large numbers of *Geocarpon* observed for that year. The alpha level for all analyses was 0.05.

RESULTS AND DISCUSSION

Population Fluctuations

Winter annual glade plants commonly exhibit annual fluctuations in population size. Available moisture for fall germination and spring growth can vary greatly, with low moisture making shallow-soiled areas hostile for plant growth. Long-term monitoring is important in order to document the range of fluctuations in population size. Knowledge of this range improves our ability to interpret population data from sites where long-term data are not available. The ability of a species' seed bank to repopulate a site after a poor seed production year has obvious implications for long-term conservation.

Results of annual *G. minimum* counts in eight plots are depicted in Figure 4. The cumulative annual totals from all eight plots ranged from one plant (1996) to 4230 plants (2003). Although all of the plots are the same size, the amount and quality of the *G. minimum* habitat within each plot varies, with some plots containing more bare rock or denser vegetative cover. Plots 6 and 7, which often contained the most *Geocarpon*, provide a greater percentage of thin soil with little competition from bryophytes, lichens, or vascular plants. The small number of *G. minimum* plants at the site in 1996 was probably due to a prolonged dry period during early spring, prior to monitoring conducted in April. Only one additional *G. minimum* plant was observed outside of the plots during that year's monitoring. More substantial numbers of *G. minimum* were found at other sites in the region that spring, indicating the critical effect of very local drought on the popula-

tion at the study site. No insect herbivory of *G. minimum* was observed at the study site or at any other Missouri sites. There was a moderate positive correlation ($r_S = 0.44$, $P < 0.001$) of *G. minimum* with year at the 1.0 m^2 scale (Table 1). Plot to plot variation was significant between 1997 and 1999 (RM: $X^2 = 11.7$, $P = 0.045$; Tukey: $q = 4.16$, $P < 0.05$). Although the population fluctuated from year to year depending on local conditions, there was an overall increase in the population over the years.

Soil Depth Considerations

The stream and sheet flow of water over the glade due to precipitation creates a dynamic environment for *G. minimum*, with the depth and location of the loose, sandy soil with small pebbles changing dramatically through time. It was not uncommon to find *G. minimum* plants that had been uprooted and probably displaced by water and soil movement. It seems likely that the succulent stems are at least somewhat tolerant of displacement and can become established at new locations, especially when partially buried in sand.

The mean soil depth for subplots containing *G. minimum* was 19 mm (Fig. 5a, b). In comparison, Somers et al. (1986) found the shallowest soil depths on xeric communities of the limestone glades of Middle Tennessee to be (35 ± 17 mm), with such areas dominated by annuals and mosses, including several endemic species. In this study, soil depth was measured at the center of each subplot rather than at the actual location of any *G. minimum* plant. Therefore the high number of subplots with zero soil depth does not imply that plants were growing on bare rock but rather that they grew within about 7 cm (the distance from the center to a corner of a subplot) of the bare rock/soil interface. Nevertheless, there was a significant association between soil depth and *G. minimum* numbers ($r_S = 0.16$, $P < 0.001$ at 0.10 m^2 scale; $r_S = 0.41$, $P < 0.001$ at 1.0 m^2 scale)(Fig. 5b and Table 1). Note that the Spearman rank correlation between soil depth and the frequency of subplots containing *G. minimum* was -0.46 (Fig. 5a). It was observed that in areas of deeper soil, perennial vascular plants were more often present. Where vascular plants become numerous, fallen leaves from trees can lodge between stems and accumulate, whereas *G. minimum*-rich areas of the glade are windblown and/or washed by moving water and remain largely free of leaves.

Shallow soil, per se, is not a requirement for *G. minimum* growth. Rather, it is the mechanism by which plant competition is minimized on the sandstone glades. This was borne out by the growth of *G. minimum* on deeper soils following removal of other vegetation and litter by prolonged inundation and wave action on the lower portions of the study site in 1993. This is also apparent with the observation that *G. minimum* grows on deeper soils in the saline prairies of Arkansas, Louisiana and Texas, where high sodium levels prevent the growth of competing vegetation. In addition, there were significant differences with soil depth and the distribution of bryophytes, lichens, and vascular plants at the 0.01 m^2 scale as indicated by the Kruskal-Wallis analysis of variance and/or the Spearman rank correlation coefficients (bryophytes: $H_4 = 19.96$, $P < 0.001$, $r_S = -0.12$, $P < 0.001$; lichens: $H_4 = 19.10$, $P = 0.002$, $r_S = -0.110$, $P > 0.05$; and vascular plants: $H_4 = 17.18$, $P = 0.002$, $r_S = 0.445$, $P < 0.001$)(Fig. 5c, d, and Table 1).

Both soil depth and the number of subplots that contain *G. minimum* passed the normality test (Kolmogorov-Smirnov $P > 0.05$). The results of the model II regression analysis show that *G. minimum* increases with increasing soil depth until about 20 mm ($F_{2, 18} = 4.45$; $P < 0.05$) albeit with a low adjusted r^2 (15.4%). The regression model accounted for fifteen percent of the variation and is consistent with the results of the Spearman rank correlations (Fig. 5a, b and Table 1). An additional regression analysis

TAB. 1. Spearman rank correlation coefficient for Year, *Geocarpon minimum*, bryophytes, lichens, vascular plants, cryptogams, total vegetation, and soil at the subplot (0.01 m^2), n = 862, (above the diagonal) and large plot (1.0 m^2), n = 50 (below the diagonal) scales. Correlations between large plot and subplot data (along the diagonal) were not calculated because the data are not paired. * = significance at the 0.05 level.

	Year	*G. minimum*	Bryophytes	Lichens	Vascular Plants	Cryptogam	Total Vegetation	Soil
Year	–	0.440*	-0.123*	-0.317*	0.022	-0.331*	-0.537*	0.038
G. minimum	0.190	–	-0.230*	-0.168*	0.186*	-0.305*	-0.236*	0.162*
Bryophytes	-0.161	-0.098	–	-0.160*	-0.577*	0.729*	0.362*	-0.118*
Lichens	-0.184	-0.045	0.367*	–	-0.442*	0.550*	0.298*	-0.027
Vascular Plants	-0.024	0.204	-0.154	-0.273	–	-0.781*	0.070*	0.165*
Cryptogam	-0.283*	-0.099	0.727*	0.829*	-0.346*	–	0.542*	-0.111*
Total Vegetation	-0.312*	-0.041	0.663*	0.755*	0.120	0.871*	–	0.043
Soil	0.042	0.408*	-0.199	-0.256	0.471*	-0.222	0.448*	–

shows that *G. minimum* numbers decrease with increasing soil depth beyond 20 mm ($F_{2, 88} = 68.45$; $P < 0.0001$) with an adjusted r^2 of 43.1% (Fig. 5a, b). These results suggest that *G. minimum* numbers increase with increasing soil depth where competition is at a minimum but decreases thereafter. The latter observation is probably due to the competition from perennial vascular plants, which are more prevalent on deeper soils.

Vegetation Correlations

Large areas of the glade's sandstone bedrock are covered with dense bryophytes and it was expected that cover measurements would demonstrate that bryophytes were spreading into *G. minimum* populations. Although bryophytes were negatively correlated with *G. minimum* numbers at the subplot scale ($r_S = -0.23$, $P < 0.001$), they were not at the large plot scale. Similar results were observed with lichens and *G. minimum* numbers in that there was a negative relationship at the subplot scale but not at the large plot scale (Table 1). Although there is some discontinuity among scale with the latter two groups, there is a strong negative association ($r_S = -0.78$, $P < 0.001$) between cryptogams (combined category of bryophytes and lichens) and *G. minimum* numbers (Fig. 5f and Table 1). The latter may suggest that cryptogam competition is a factor in depressing *G. minimum* populations.

A positive association occurred with coverage by vascular plants and *G. minimum* ($r_S = 0.19$, $P < 0.001$) at the small plot scale but not at the next scale (Fig. 5e and Table 1). It may be that through time *G. minimum* has persisted only on those areas of the glade that are subjected to the same periodic disturbances that make it difficult for mosses and vascular plants to become established. Lichen cover declined steadily from 35.1% in 1994 to 10.9% in 1998. Perhaps this aspect of the monitoring would show better statistical trends if conducted over a longer period and with more detailed data collection with respect to the species of vascular plants and cryptogams across population sites. Certainly the movement of soil over the bedrock would explain the erratic variation in numbers of subplots dominated by bare soil or bedrock. There are similarities between *G. minimum* population dynamics and winter desert annuals in that there are large population number changes from year to year. Guo et al. (2002) discussed dramatic fluctuations in abundance, productivity, and diversity among desert winter annuals. Furthermore, the population dynamics of *Vulpia ciliata* Link. has been well studied (Watkinson et al. 2000; Watkinson 1990; Watkinson & Davy 1985; Watkinson & Harper 1978). This annual grass,

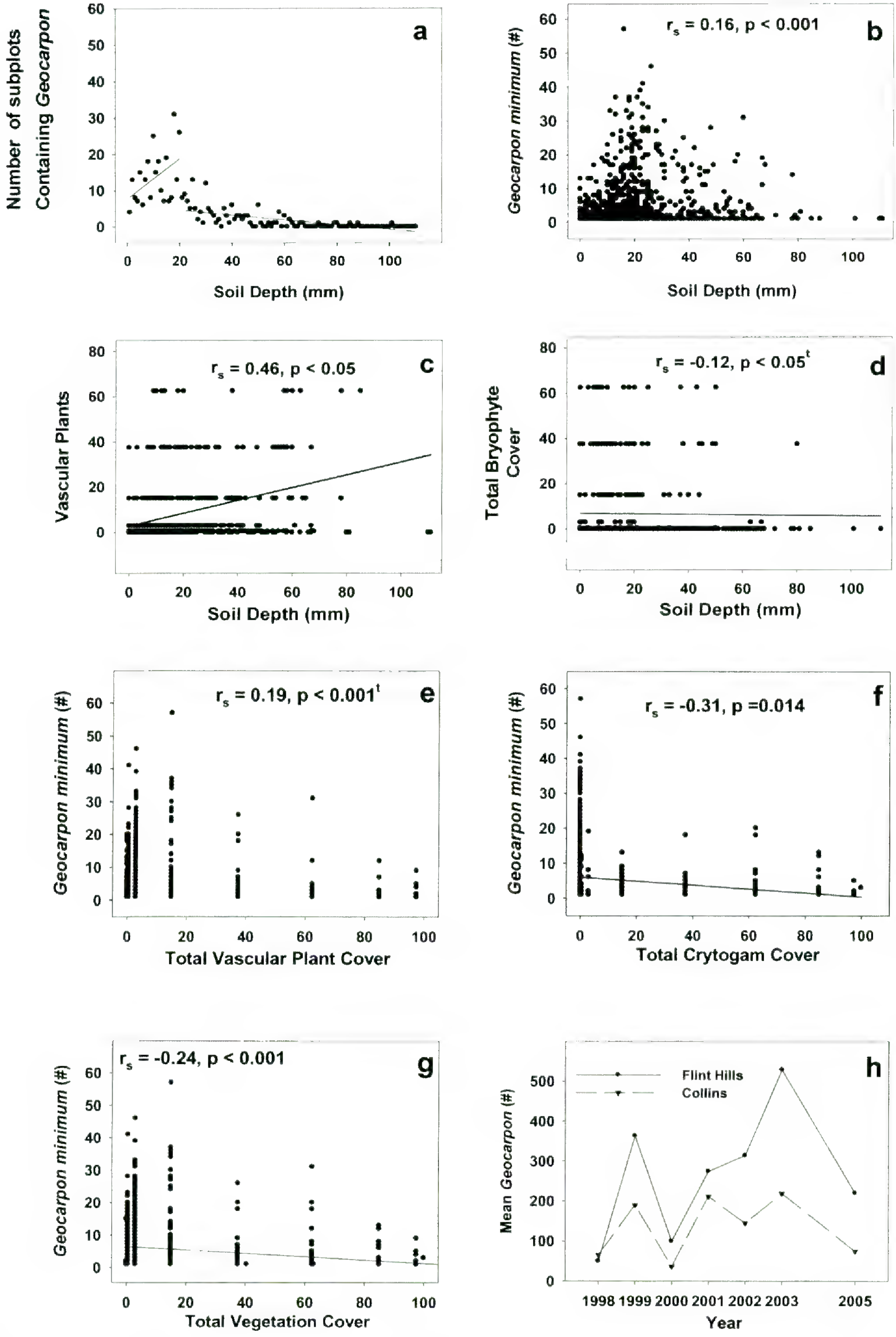


FIG. 5. Scatter plots of *G. minimum*, soil depth (millimeters), other vegetation types, with corresponding Spearman rank correlation coefficients and best fit lines, and population numbers of *G. minimum* from two populations (Flint Hills Glade and Collins relocation Site, Dade and St. Clair counties, Missouri). t indicates significance only at the large (1.0 m^2) plot scale.

occurring on sandy heaths and warrens along coastal England, has similarities to *G. minimum* populations in that population dynamics probably occur at very small scales. It has been shown that other vegetation types depress *V. ciliata* populations significantly.

The coupled effect of all vegetation upon *G. minimum* populations further exemplifies that the persistence of this taxon may be dependent upon periodic disturbances. There was a significant negative correlation with *G. minimum* numbers at the subplot level (r_S = -0.24, $P < 0.001$) with the combined vegetation cover (cryptogams and vascular plants) (Fig. 5g and Table 1).

Colonization Plots

The three plots that were created in 1995 by removal of dense moss were not colonized by *G. minimum* during the study. Instead they were eventually recolonized by the moss, although there were several years following establishment when the habitat appeared suitable for *G. minimum*. The fact that these plots were nearly surrounded by undisturbed areas of dense moss may have precluded the water-transport of *G. minimum* seeds to the plots. Krieger et al. (2003) studied the temporal dynamics of ephemeral plant communities in seasonal rock pools on Ivorian inselbergs, monolithic outcrops of granites and gneisses along the Ivory Coast of Africa. These rock pools or depressions are typically several hundred years old and are seasonally wet with local edaphic conditions that may be typically xeric with a thin soil layer. They observed that plant communities in seasonal pools tend to follow the 'turnover hypothesis' which states that species that occur in discrete subpopulations tend to be at dynamic equilibrium with extinction and colonization. The turnover hypothesis is a significant part of island biogeography theory (MacArthur & Wilson 1967). The authors also noted that the turnover rate of an annual, *Cyanotis lanata* Benth. (Commelinaceae), was higher than other species. Although turnover was not studied here, the fluctuation in *G. minimum* population numbers from year to year may suggest that turnover does occur. The extent to which it may occur needs further study. Furthermore, Krieger et al. (2003) also examined physical characteristics of depressional pools including area, mean depth, volume, water depth, and precipitation for these rock pools. It seems that distance between pools limits the 'rescue effect', or the migration of propagules between pools. *G. minimum* gene flow among and between populations and subpopulations should be ascertained to determine if these populations are indeed isolated or have metapopulation characteristics.

To effectively establish *G. minimum* in additional plots, it is possible to move seeds into plots following soil disturbance. This has been done successfully at a highway mitigation site in St. Clair County, Missouri (Smith & Gardner 1999) by moving soil in the summer from areas where *G. minimum* had grown during the spring. It would seem prudent, however, to select establishment sites that are not subject to rapid recolonization by competitive plant species or offset recolonization by competitors with sufficient disturbance. The current study casts doubt on the efficacy of relying on an existing *G. minimum* seed bank in the created plots or on the rapid, natural dispersal of seeds into the newly-available habitat.

Climatic Effects

An aspect of this study that needs further work is the relationship between local and regional weather conditions and *G. minimum* populations. A graphical comparison of *G. minimum* populations between Flint Hill Glades and a relocated population, St. Clair County, Missouri, (Smith & Gardner 1999) shows a high degree of symmetry among popu-

lation numbers among years, indicating that precipitation and or temperature may play a key role (Fig. 5h). The differences between populations in particular years (2001 to 2002) may indicate that local precipitation and or temperature events may also influence geographically distinct populations. Weather data should be collected on each site for most accurate correlations because very local drought conditions at presumed critical life stages (fall germination of seed and early spring growth) would not be captured by available regional weather station measurements.

Management Implications

The long-term monitoring of *G. minimum* at Flint Hill Glades ecosystem provided insight on effective management of this threatened species. There is a negative association of cryptogams and the population of *G. minimum* as evidenced by the Spearman rank correlations (Fig. 5f and Table 1). Furthermore, *G. minimum* seems to utilize habitats where there is periodic soil disturbance and minimal competition from mat-forming mosses or perennial vascular plants. The level of soil disturbance necessary to keep water-carried sand moving into bedrock depressions will be difficult to quantify.

Geocarpon minimum population numbers appear at least partially dependent upon the amount of soil present (Fig. 5a, b; Table 1) as indicated by the results of the analysis of variance and type II regression, but there are other unknown factors that affect *G. minimum* numbers. Some level of grazing by cattle may benefit the plant by maintaining areas of loose sand with minimal plant competition, but excessive trampling or nutrient deposition would be a concern. Although it seems that many of the moss-dominated areas of the glade are currently unsuitable for *G. minimum*, we have little information on how abundant or widespread *G. minimum* was historically on Missouri's sandstone glades. Fire suppression following settlement of the region has nearly eliminated a critical process that may have previously altered the ratio of bare soil to heavily-colonized soil.

Management recommendations include providing periodic soil disturbances to the glade to assure that loose, sandy soil is available for movement by surface water. The periodic movement and accumulation of sand into shallow bedrock depressions should facilitate the development of suitable *G. minimum* habitat. Further studies are needed to address the frequency and type of disturbance required to achieve this result. More work is needed on the autecology and synecology of this taxon and associated species at other *G. minimum* suitable habitats. In addition, the physical environment needs to be characterized, as well as local and regional climate. It is encouraging that *G. minimum* was more abundant in the plots at this study site in 2003 than during any of the previous nine years and that the population is capable of rebounding following a year with little seed production.

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Book Review

Ria Loohuizen. 2006. **On Chestnuts: The Trees and Their Seeds**. (ISBN 1-903019-832-3, pbk.). Prospect Books, Allaleigh House, Blackawton, Totnes, Devon, TQ9 7DL, U.K. (**Orders:** www.oxbowbooks.com, 1-800-791-9354). $17.95, 136 pp., 5 1/2" × 7 1/4".

"Chestnuts roasting by an open fire..." We are all familiar with the Bing Crosby song *White Christmas*, but few of us are familiar with the history and lore of the chestnut. Growing up in North Texas, I did not see a chestnut tree until I was an exchange student in Northern Ireland. The huge tree with its gigantic nuts made quite an impression when I came upon it in the dark Irish woods. Ria Loohuizen, a translator living in Amsterdam and the author of *The Elder*, has written a lyrical account of the horse chestnut and the sweet chestnut, complete with medicinal uses, historical notes, beautiful quotes from writers and poets, and recipes that are a wild food gourmet's delight. The petite book is divided into a section on horse chestnut, *Aesculus hippocastanum*, and a longer section on the European sweet chestnut, *Castanea sativa*. It is full of interesting facts. For example, the horse chestnut may have gotten its common name from the horseshoe-like shape of its leaf scars and the genus name *Castanea* is probably derived from the name of a city in Turkey. The sweet chestnut is native to southern Europe, the Caucasus, and North Africa. It is believed to have been brought to Europe by the Celts. A significant section of the book is devoted to the culinary applications of the sweet chestnut, which is the only nut with high levels of vitamin C, according to the author. The recipes include such delicacies as the classic roasted chestnuts, pumpkin chestnut soup, Roman-style chestnuts with lentils, chestnut bread, chestnut cookies, and several recipes for chestnut poultry stuffings. There are also cosmetic recipes, including an intriguing recipe for a hair conditioner made from horse chestnut leaves. Other interesting tips abound, such as using crushed horse chestnuts to keep insects out of potted plants. Recently, the horse chestnut has gained attention as the source of a treatment for chronic venous insufficiency (Suter et al. 2006). The American chestnut tree, *Castanea dentata*, has been a beloved fixture in the forests of the east coast of the United States, but it has been decimated by chestnut blight, a fungal disease imported from Asia. Let us hope that this book is not a eulogy, but rather an ode to the remarkable chestnut.—*Marissa Oppel, MS, Collections and Research Assistant, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

REFERENCES

Suter, A., S. Bommer., and J. Rechner. 2006. Treatment of patients with venous insufficiency with fresh plant horse chestnut seed extract: a review of 5 clinical trials. Adv Ther. 23:179-190.

A QUANTITATIVE STUDY OF STYLES AND ACHENES OF TERMINAL AND BASAL FLOWERS OF *SCHOENOPLECTUS HALLII* (CYPERACEAE), A RARE PLANT SPECIES OF TRANSIENT WETLAND HABITATS

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ABSTRACT

Schoenoplectus hallii (A. Gray) S.G. Smith (Cyperaceae), a rare plant restricted to wetland habitats, is of conservation concern throughout its range. Taxonomy of the species recently has been clarified; however, quantitative descriptions of achene and flower morphology are incomplete and life history information is lacking. Because of its scarcity and the transient nature of populations, any large-scale study of the species will require the recovery of achenes from bulk soil samples and the identification and separation of the dimorphic achenes. The objectives of this study were to separate, identify and photograph the two achene types; to quantify the size and morphological differences that will be useful in separating terminal and basal achenes; and to determine the range of variability in style morphology and achene size within and among 12 populations in four states. Although each achene type varies significantly in size among populations, size differences between terminal and basal achenes are statistically significant, and the range of sizes within each achene type is larger than has been previously reported. Terminal achenes are significantly smaller in length, width, beak length, mass and surface area than basal achenes, and noticeable differences occur in surface ridging. Differences in style morphology are distinct: terminal flower styles are predominantly bifid and consistent in shape, while basal flower styles, which are six times longer than terminal styles, are trifid with a wide variety of branching patterns. Terminal and basal achenes can be separated accurately and conveniently from bulk soil samples using a series of soil sieves. The visual and quantitative descriptions provided in this study will facilitate the collection and identification of terminal and basal achenes of *S. hallii* from plants, soil and wildlife.

RESUMEN

Schoenoplectus hallii (A. Gray) S.G. Smith (Cyperaceae), una planta rara restringida a hábitats de lugares húmedos, es para ser conservada en toda su área. La taxonomía de la especie se ha clarificado recientemente; sin embargo, las descripciones cuantitativas del aquenio y la morfología floral son incompletas y falta información de su ciclo vital. Debido a su escasez y a la naturaleza transitoria de sus poblaciones, cualquier estudio a gran escala de la especie requerirá la recuperación de aquenios a partir de grandes muestras de suelo y un método adecuado de identificación y separación de los aquenios dimórficos. Por lo tanto, los objetivos de este estudio fueron separar, identificar y fotografiar los dos tipos de aquenio; cuantificar el tamaño las diferencias morfológicas que serán útiles en la separación de los aquenios terminales y basales; y determinar el rango de variabilidad en la morfología del estilo y tamaño del aquenio en y entre 12 poblaciones en cuatro estados. Aunque cada tipo de aquenio varía significativamente en tamaño entre poblaciones, las diferencias de tamaño entre aquenios terminales y basales son significativas estadísticamente, y el rango de tamaño para cada tipo de aquenio es mayor de lo que se había indicado previamente. Los aquenios terminales son significativamente más pequeños en longitud, anchura, longitud el pico, masa y área de su superficie que los aquenios basales, y hay diferencias notables en las costillas de la superficie. Las diferencias en la morfología del estilo son distintas: los estilos de las flores terminales son predominantemente bífidos y de forma constante, mientras que los estilos de las flores basales, que son seis veces más largos que los estilos de las flores terminales, son trífidos con una amplia variedad de patrones de ramificación. Los aquenios terminales y basales pueden separarse con precisión y de un modo práctico a partir de muestras de suelo voluminosas usando una serie de cribas para suelos. Las descripciones visuales y cuantitativas aportadas en este estudio facilitarán la recolección e identificación de aquenios terminales y basales de *S. hallii* a partir de plantas, suelo y de la naturaleza.

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INTRODUCTION

Schoenoplectus hallii (A. Gray) S.G. Smith is a member of the family Cyperaceae. Asa Gray (1863) described the species as *Scirpus hallii* A. Gray, based on specimens collected in Illinois. Recent work by Smith (1995) and Smith and Yatskievych (1996), however, has emphasized the breakup of the polymorphic supergenus *Scirpus* sensu lato and resulted in the acceptance of *Schoenoplectus hallii* as the appropriate binomial for the species (Smith 1995, 2002).

The known distribution of *S. hallii* prior to 1973 extended from Massachusetts to Wisconsin and Iowa on its northern boundary, westward to Kansas and Nebraska, and south to Georgia. The number of states in which populations existed declined from nine in 1973 to six in 1997 (McKenzie 1998). It has apparently been extirpated from Massachusetts and Georgia, and is now restricted to the Midwest. In 2000, *S. hallii* was reported from 14 sites in Oklahoma (Magrath 2002); however, the conservation status of the species at these sites is unclear due to the recent discovery of putative hybrids (*S. hallii* × *S. saximontanus*) at some of the sites (Smith et al. 2004). In 2002, surveys for *S. hallii* revealed new populations in several states, including Indiana (M. Homoya, pers. comm.) and Missouri (pers. obs.) and Texas (O'Kennon and McLemore 2004). In years not suitable for germination, the species may persist only in the seed bank (McKenzie 1998); therefore, it is difficult to obtain accurate estimates of the number of viable populations in any given year. Although population number and geographical distribution are not clearly defined, *S. hallii* is considered to be of conservation concern in every state in which it occurs (Beatty et al. 2004).

Schoenoplectus hallii is restricted to wetland habitats (Swink & Wilhelm 1994; McClain et al. 1997) in areas characterized by fluctuating water levels (Ostlie 1990; Ostlie & Gottlieb 1992; Robertson et al. 1994). The species is thought to have a persistent seed bank (Ostlie 1990; Ostlie & Gottlieb 1992; Robertson et al. 1994) that may contribute to its potential for population regeneration. Achenes germinate sporadically, depending on the availability of wet, exposed habitat (McKenzie 1998), resulting in wide fluctuations in population number and size from year to year (Chester 1988; Robertson et al. 1994, McClain et al. 1997). It has been suggested that because of loss of suitable wetland habitat, management of *S. hallii* sites is necessary to ensure the species' continued existence (Bowles et al. 1990; Robertson et al. 1994).

Schoenoplectus hallii exhibits amphicarpy (Bruhl, 1994), as do other members of the section *Supini* (i.e., *S. erectus* and *S. saximontanus* in North America), and achenes produced in multi-flowered spikelets near the tip of stems (hereafter designated as "terminal" achenes or flowers) have been illustrated and/or described by various authors (Gleason & Cronquist 1963; Mohlenbrock 1963; Steyermark 1963; Radford et al. 1964; Mohlenbrock 1976; Kolstad 1986; Yatskievych 1999; Smith 2002). Although achene size is estimated in the taxonomic literature, and varies among authors, a quantitative measure of variation in achene size from a representative sample of populations across the range of the species is lacking. Basal achenes, which are produced by solitary pistillate flowers enclosed within the leaf sheaths at culm bases, are less adequately illustrated and described than terminal achenes. With the exception of a photograph of one basal achene (Schuyler 1969) no photographs or illustrations have been published. In addition, no quantitative description of variation in basal achene size within and among populations exists. Quantitative data establishing the size and morphology of the basal achenes are important for the correct separation and identification of seed bank components and are

essential for the development of life history studies that estimate the relative reproductive contribution of basal achenes to population size.

In early summer before achenes have been produced, style lobe number is the morphological character most useful in separating *S. hallii* from *S. saximontanus*, because of their similar vegetative appearance. As far as we are aware, there has been no large-scale study of style size and morphology in *S. hallii*. Recently, *S. hallii* and *S. saximontanus* were found growing in mixed populations in Oklahoma (Magrath 2002); therefore, it would seem prudent to determine if style lobe number is constant throughout a number of widely distributed populations of *S. hallii* in areas where *S. saximontanus* is not sympatric to confound the issue.

The objectives of this study were **1)** to develop a simple procedure for separating, collecting and identifying achenes from bulk soil samples; **2)** to photograph the two achene types; **3)** to quantify the size and morphological differences that will be useful in separating terminal and basal achenes; and **4)** to determine the range of variability in style morphology and achene size within and among 12 populations in four states (IL, IN, KY, and MO).

MATERIALS AND METHODS

When possible, living plants were collected *in situ* and transferred to the greenhouse at Southern Illinois University, Edwardsville, IL. Plants were potted in a 75%-sand:25%-potting soil mixture in 10 × 10 × 11 cm pots, covered with a plastic bag to decrease transpirational water loss, and placed in flats in 5 cm of standing water. The organic content of the mixture (%OM = 2.5%) was approximately that of soil at the study sites (mean %OM = 2.6±0.5%, analyses conducted by Alvey Labs, Belleville, IL). Plants were given identifying numbers and mature terminal achenes (and basal achenes, when present) were collected and saved for measurement. Otherwise, basal achenes were collected as they matured.

Site names, acronyms, approximate locations (exact locations are not listed to protect population sites) and dates of collection are listed in Table 1. At three sites that were without plants (SP, FO and KY), but were known to have had populations of *S. hallii* within the past 5 years, soil cores were collected to provide a seed source. In all cases, plants or cores were collected at regular intervals along transects from across the known extent of the population. To ensure accurate identification of achene types, initial collections were of terminal and basal achenes that were attached to the parent plant. After achene identification was established, others were collected from soil samples. Whenever possible, pairs of terminal and basal achenes were selected, using a random number table, from 15 plants and photographed, measured and weighed in the laboratory. For sites without plants, soil sieves (U.S. Standard by Fisher Scientific Co) #16 (1.18 mm mesh), #18 (1.00 mm) and #20 (0.841 mm) were used to separate basal and terminal achenes. Identification was verified using a dissecting microscope. As some achenes that appeared to be healthy and mature fragmented when pressed between the thumb and forefinger, all achenes were given this preliminary test before being measured (Baskin et al. 2003).

Achene photographs were made using a Nikon CoolPix 995 digital camera mounted on a Nikon dissecting microscope (Model SMZ800) fitted with a fiber optic ring-light. Length, width, and beak measurements were taken at a magnification of 40X using a Leitz compound microscope (Model Laborlux S) and a Bausch and Lomb ocular micrometer that was calibrated with a Leitz stage micrometer. Achene beak length was measured from the point where tangential lines drawn at the top of the achene and alongside the

TABLE 1. Names, acronyms and county and state locations of 12 *Schoenoplectus hallii* sites and types of samples collected for this study.

Site	State	County	Date and Sample Collected
Ebken (EB)	IL	Mason	2000 Plants and soil
Fornoff (FO)	IL	Mason	2000 Soil only
Sand Pond (SP)	IL	Mason	2000 Soil only
Wemker (WK)	IL	Mason	2000 Plants and soil
Indiana (IN)	IN	Daviess	2002 Plants and soil
Kentucky (KN)	KN	Christian	2000 Soil only
Baptist Camp (BC)	MO	Scott	2000 Plants and soil
Howell County (HC)	MO	Howell	2002 Plants and soil
Petite Isle (PI)	MO	Scott	2002 Plants and soil
Sherer (SH)	MO	Scott	1999–2001 Plants and soil
Waterman (WM)	MO	Scott	2002 Plants and soil
West Vaco (WV)	MO	Scott	2002 Plants and soil

beak intersected (Fig. 1). As beak length varied considerably, but contributed little to achene area, achene surface area was calculated as width × (achene length–beak length). Mass was determined using a Mettler analytical balance (Model AT 261 Delta Range). To illustrate the contrast in size, one pair of terminal and basal achenes were photographed with attached styles (Fig. 2A). To illustrate variability in basal and terminal achene morphology, three of each achene type were photographed in the same field-of-view (Fig. 2B). Also, three achenes of each type were photographed in cross-section (Fig. 2C) and one pair of achenes was photographed showing the achenes in frontal (Fig. 2D) and profile (Fig. 2E) views.

Styles were excised from flowers of each type, floated on water and measured. For statistical analysis, measurements were made on terminal styles from 15 plants from eight populations, but for basal styles, which are scarce and difficult to collect intact, measurements were limited to 15 plants from one population. Others from eight additional populations were observed for style morphology, but not measured. To illustrate some of the variation in style morphology observed in basal flowers, drawings were made to scale (Fig. 3B–D).

When data sets for terminal and basal achenes were combined for analysis, variances were significantly different ($P<0.001$) between achene types for all dimensions; therefore, analysis by two-way ANOVA was rejected and data for each achene type were analyzed separately by one-way ANOVA. Equal variance was verified using Levene's Test and data were log transformed, when necessary, to ensure normal distribution. Comparisons of mean values for achene characteristics among sites were determined by Bonferroni's t-test. Terminal style measurements, for which data could not be successfully transformed, were analyzed by Kruskal-Wallace one-way ANOVA on ranks, followed by Tukey's t-test for comparison of means. Pooled differences in dimensions between achene types were determined by t-test, assuming unequal variances. When matched pairs of terminal and basal achenes were available within a population, statistical comparisons were made using a paired-samples t-test. All statistical procedures were calculated using SPSS 11.4 (SPSS, Inc. 2002) and are in accordance with Sokal and Rohlf (1981). Principle ANOVA statistics, means, and P-values) were reported when differences were statistically significant.

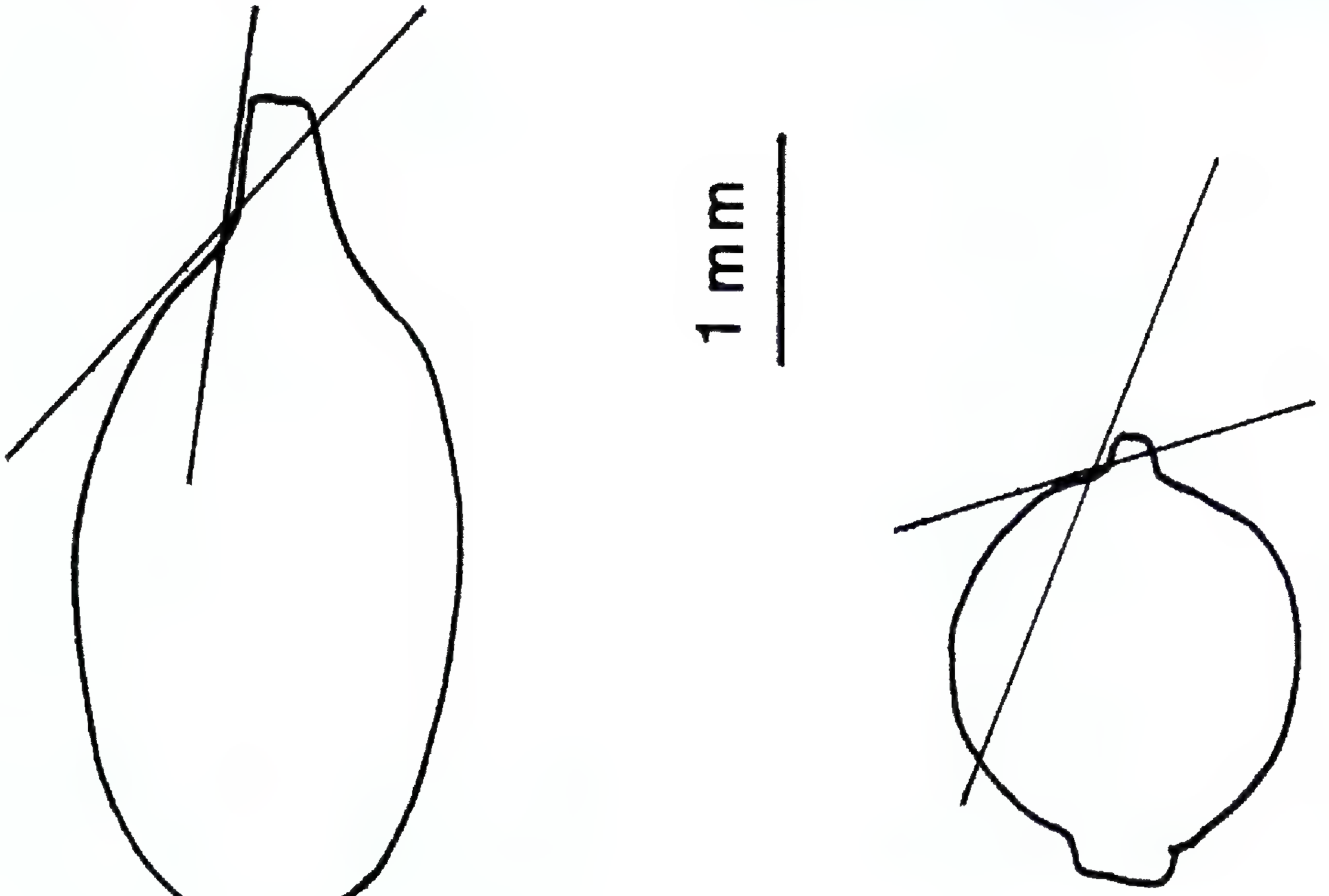


FIG. 1. Method for determining beak length in basal (left) and terminal (right) achenes of *Schoenoplectus hallii*. Drawn to scale as indicated in the figure.

RESULTS

Comparisons among populations

Terminal achenes.—Terminal achenes varied significantly in every dimension (length, width, beak length, mass and surface area) among populations (Table 2, Fig. 4A–E). Achenes from HC were significantly larger than those from all other populations, with the exception of beak length (Table 3). There was a wide range in terminal achene size and mass (Table 4), even with the removal of the extremely large mean values for HC achenes, which, when included, raised the upper limit for every character.

Terminal styles.—All terminal styles examined were bifid, with the exception of the one 4-parted style from HC. There was a much wider range in style length compared to the range for any achene character (Table 4). There were significant differences in style length among populations (Table 2): the styles of the WK population were longer than those from any other site and the styles from the SH site significantly longer than all except those from WK ($P<0.05$). There were no significant differences in style lengths among the other six sites.

Basal achenes.—Basal achenes were more varied in shape than terminal achenes (Fig. 2B); however, there were significant differences among populations for every basal achene character measured (Table 5). Unlike the case with terminal achenes, in which those from HC were significantly larger than those from all other sites, no single population had consistently larger basal achenes (Fig. 5A–E, Table 6).

Comparisons between terminal and basal achenes and styles.—Pooled means for every

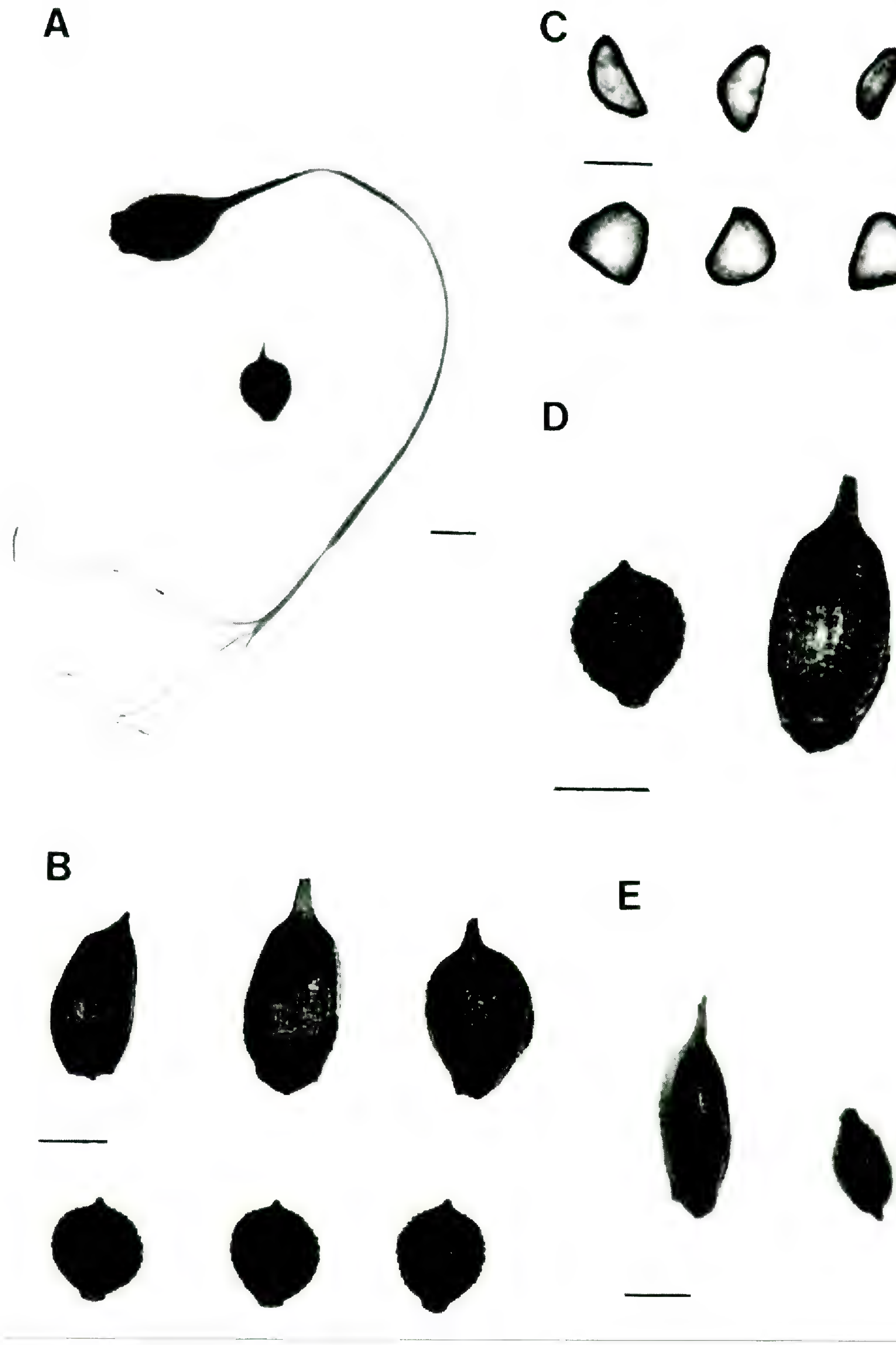


Fig. 2 A–E. A. Basal (top) and terminal achenes of *Schoenoplectus hallii* with attached styles; B. adaxial view of basal achenes (top) and terminal achenes of *S. hallii*; C. cross sectional view of terminal (top) and basal achenes of *S. hallii*; D. close-up of terminal (left) and basal achenes of *S. hallii*; and E. profile view of basal (left) and terminal achenes of *S. hallii*. Bars on all photographs are 1 mm in length.

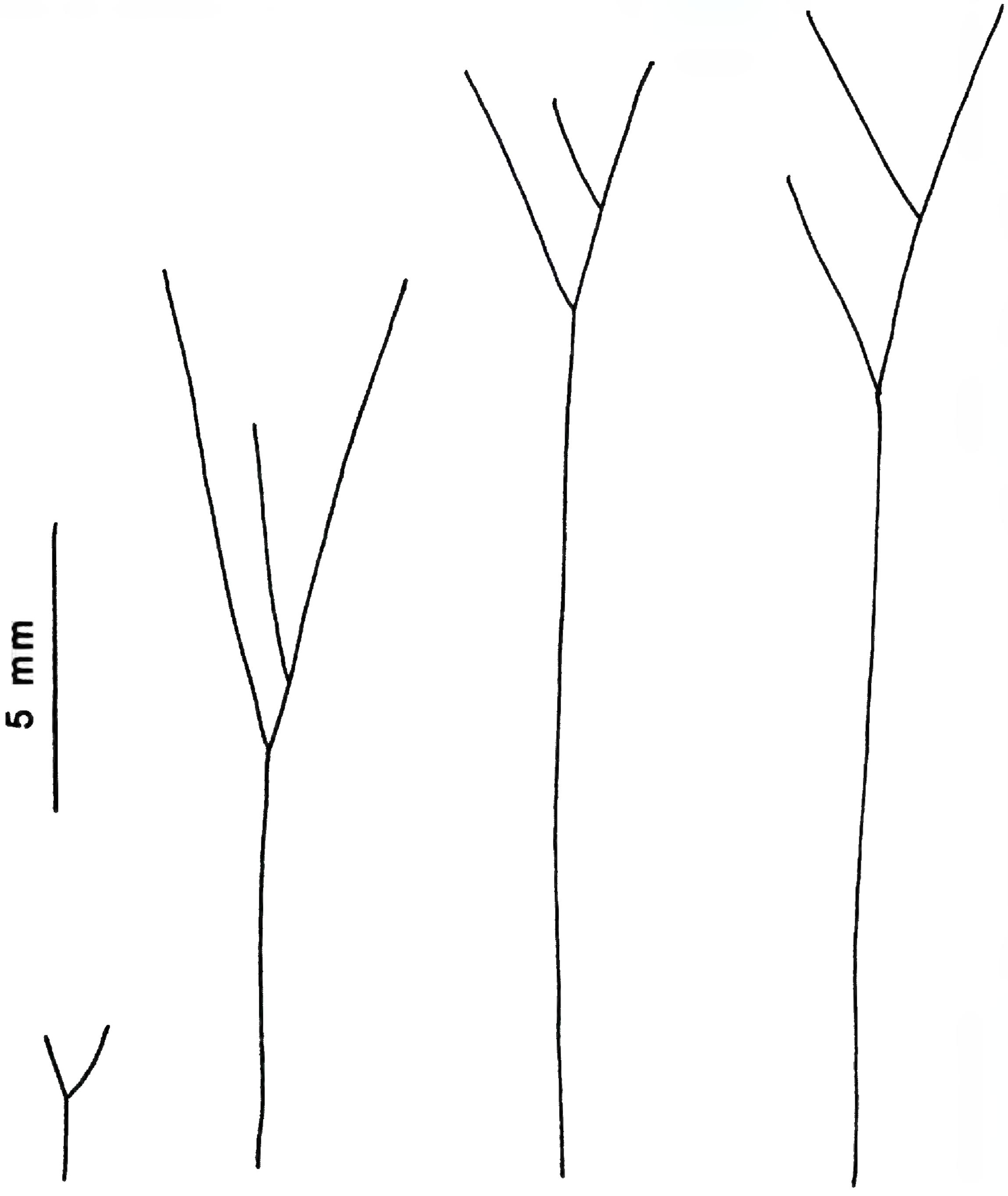


FIG. 3 A–D. Representative styles of A. terminal and B–D. basal flowers of *Schoenoplectus hallii*.

dimension measured were significantly larger for basal compared to terminal achenes (Table 4, $P<0.001$, df = 289 for each comparison). Within-population comparisons for the nine sites for which achene pairs were available indicated that in seven populations (EB, WK, IN, BC, SH, WM, WV), basal achenes were significantly larger for all dimensions. At HC, area was not significantly different between terminal and basal achenes ($P\leq0.536$, df

TABLE 2. Summary ANOVA statistics for terminal achenes and styles of *Schoenoplectus hallii* from 12 population sites.

Character	Source of Variation	SS	df	MS	F	*P*
Length	Between pops	2.457	11	0.223	28.656	<0.001
	Within pops	1.310	168	0.008		
Width	Between pops	3.241	11	0.295	45.384	<0.001
	Within pops	1.091	168	0.006		
Beak length	Between pops	0.056	11	0.005	10.136	<0.001
	Within pops	0.085	168	0.001		
Area	Between pops	23.54	11	2.132	61.447	<0.001
	Within pops	5.829	168	0.035		
Mass	Between pops	4.092	11	0.372	26.263	<0.001
	Within pops	2.380	168	0.014		
Style	Between pops	24.163	11	3.452	15.980	<0.001
	Within pops	27.193	168	0.216		

= 11), and at PI, width for terminal and basal achenes did not differ significantly ($P \leq 0.348$, df = 14).

All terminal achenes examined had prominent transverse ridging extending the width of the achene surface as recently reported for *S. hallii* achenes from Oklahoma populations (Magrath 2002). In contrast, transverse ridging was less conspicuous and did not extend the entire width of basal achenes, which had obvious vertical ridges. The cross-sectional shape of achenes was generally as described by Yatskievych (1999) ("unequally biconvex in cross-section, sometimes slightly concave on 1 side" and "unequally 3-angled," for terminal and basal achenes, respectively); however, both achene types occasionally varied from these descriptions. Some terminal achenes were plano-convex as illustrated in Figure 2 C.

Styles of basal flowers were approximately 6 times longer than those of terminal flowers (Fig. 2A, Table 4), and exhibited a wide variety of structural morphologies. Styles of all terminal flowers examined were bifid (Fig. 3), with the exception of one style from HC that had four style lobes (not shown). All styles from basal flowers were trifid with a variety of branching patterns, some of which are illustrated in Fig. 3B–D.

DISCUSSION

A.C. Martin, a U.S. Fish and Wildlife Service biologist stated that when identifying achenes encountered in the stomachs of wildlife, his staff found the description of *Scirpus* achenes in the taxonomic literature was unhelpful in separating species (Martin 1943). Although he stated that achenes of some species are distinctive enough to present no problem in identification, "the difficulty and danger involved in attempting to distinguish some of the other species important to wildlife frequently necessitated noncommittal conservatism." These troublesome species included what is now known as *Schoenoplectus hallii*, and, although descriptions of its achenes are far more comprehensive now than in 1943, no taxonomic reference adequately describes the variation of achene size and shape existing within the species. Our data clarify and illustrate the distinctions between achene types and expand the range of achene dimensions cited in the current published literature. While several publications (Beetle 1942; Magrath 2002; Schuyler 1969; Smith & Yatskievych 1996; Smith 2002) stated clearly that *S. hallii* exhibits amphicarpy, many

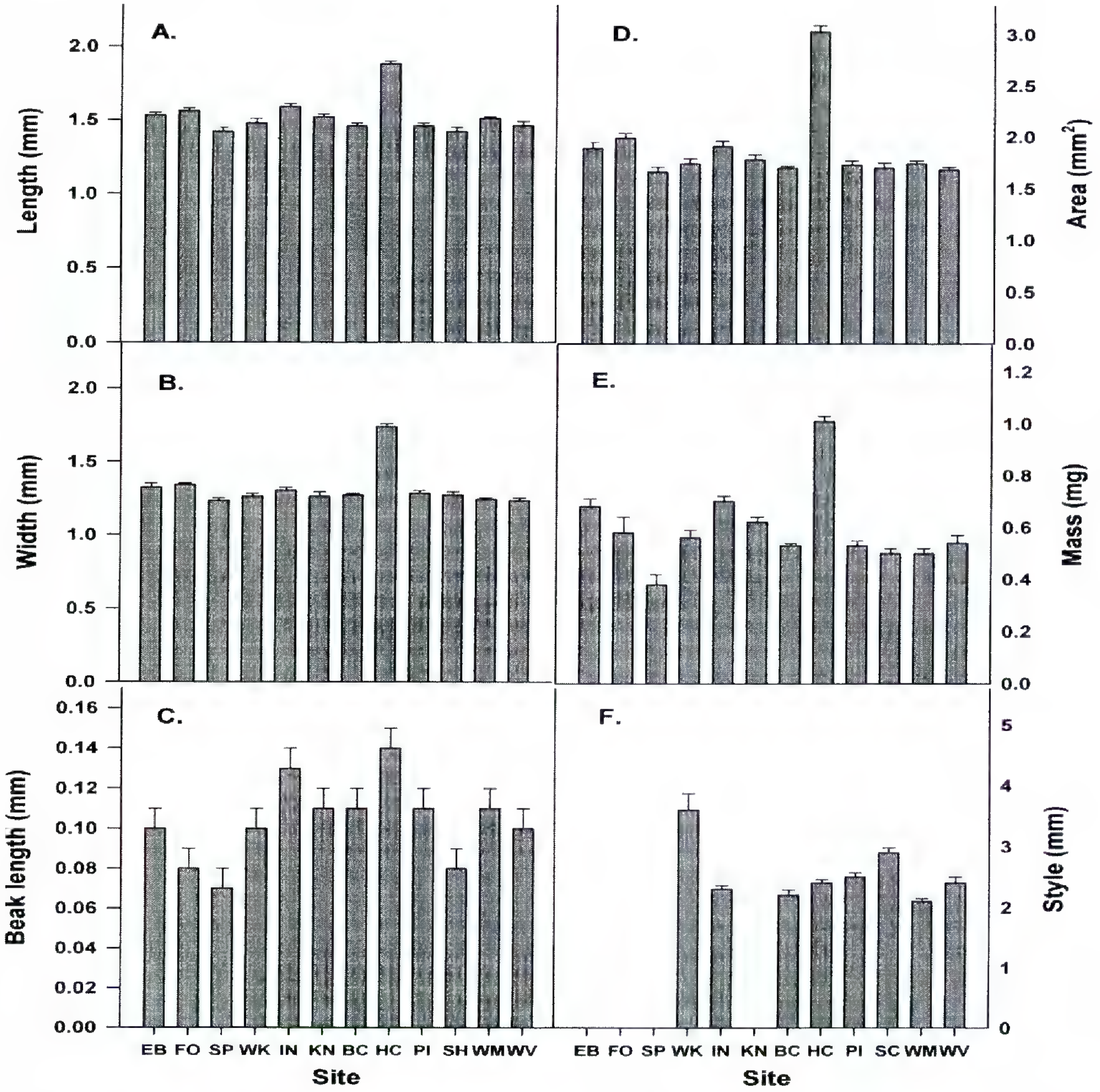


FIG. 4 A–F. A. Length, B. width, C. beak length, D. area, and E. mass of terminal achenes of *Schoenoplectus hallii* from 12 populations, and F. style length of terminal flowers of *S. hallii* from 8 populations. Each bar represents the mean ± SE of 15 measurements.

did not (Mohlenbrock 1963; Radford et al. 1964; Steyermark 1963; Kolstad 1986; Rolfsmeier 1995). Of those that recognize variation in floral types, only three provided estimates of basal achene size (Schuyler 1969; Yatskievych 1999; Smith 2002), and none presented data to quantify differences between terminal and basal achenes, nor any measure of the variance in size within achene type across a range of populations.

Although there is general agreement between our achene-size data and published reports, there are notable differences. With the exception of the three cases where size of basal achenes was specifically addressed (i.e., Schuyler 1969; Yatskievych 1999; Smith 2002), we assumed that all published estimates referred to terminal achenes. Six authors listed the following estimates of length for terminal achenes: 1.3–1.7 mm (Yatskievych 1999); 1.5–2.0 mm (Mohlenbrock 1976); "up to" 1.5 mm (Kolstad 1986); 1.3–1.5 mm (Gleason & Cronquist 1963); "less than" 0.4 mm (Robertson et al. 1994); and 1.3–1.7 mm (Smith 2002). There are three estimates of achene width in the literature: 1 mm (Beetle 1942),

TABLE 3. Significant differences in mean length, width, beak length, beak length and mass of terminal achenes among 12 populations of *Schoenoplectus hallii*. All *P* values calculated by Bonferroni's t-test.

Length	*P*	Beak	*P*	Area	*P*	Width	*P*	Mass	*P*
HC vs All	<0.001	IN vs FO	<0.001	HC vs All	<0.001	HC vs All	<0.001	HC vs All	<0.001
FO vs SP	<0.001	vs SP	<0.001	FO vs SP	<0.001	SH vs SP	≤0.014	SP vs All	≤0.040
vs SH	≤0.002	vs SH	<0.001	vs WK	≤0.019	SH vs WV	≤0.018	IN vs BC	≤0.007
IN vs SP	<0.001	HC vs EB	≤0.002	vs BC	≤0.002	–	–	vs PI	≤0.009
vs BC	≤0.006	vs FO	<0.001	vs PI	≤0.016	–	–	vs SH	<0.001
vs SH	<0.001	vs SP	<0.001	vs SH	≤0.002	–	–	vs WM	<0.001
vs PI	≤0.018	vs WK	≤0.003	vs WM	≤0.002	–	–	–	–
vs WV	<0.011	vs SH	,0.001	vs WV	,0.001	–	–	–	–

TABLE 4. Pooled means ± SE and range of values for length, width, beak length, area and mass for terminal (T) and basal (B) achenes, and styles of terminal achenes of *Schoenoplectus hallii* from 12 population sites. *Omitting extreme values from Howell County **Mean values of basal styles from SH only.

	T Mean	T Range	T Range*	B Mean	B range
Length	1.52±0.01	1.14–2.7	1.14–1.76	2.30±0.03	1.20–3.11
Width	1.32±0.02	0.88–1.88	0.88–1.50	1.43±0.01	1305–1.93
Beak length	0.11±0.00	0.04–0.22	0.04–0.18	0.34±0.03	0.11–0.90
Area	1.88±0.03	1.12–3.32	1.12–2.42	2.81±0.04	1.64–4.32
Mass	0.60±0.01	0.23–1.13	0.23–0.95	1.68±0.04	0.85–2.83
Style	3.25+0.06	1.30–6.00	1.30–6.00	17.07±0.89**	12.00–22.00**

1.2–1.5 mm (Radford et al. 1964) and 1.2–1.3mm (Smith 2002). With the exception of the measurement reported by Robertson et al. (1994), which undoubtedly refers to beak length, as previously stated in Schuyler (1969), rather than achene length, all measures of terminal achenes are within a reasonable range; however, the incomplete dimensions given in any single source create uncertainty in identification or confirmation of achene identity. As we have demonstrated, size can vary significantly between sites, and in exceptional cases (e.g., HC) the variation is so extreme that the achenes of *S. hallii* could be misidentified if size, as described in the existing taxonomic literature, was included in the criteria for identification. As it is not customary for authors of taxonomic literature to indicate the sample sizes upon which their estimates are made, it is possible that some are based on a single achene, although most cite a range in size, which implies more than one measurement. In any case, it is time that a clearer delineation of the range of dimensions in achenes becomes available in the published literature.

Relying solely on information in the taxonomic literature, it is possible that someone examining the seed bank of *S. hallii* could fail to recognize basal achenes as belonging to the species, and thus underestimate the potential population size or the contribution of basal achenes to it. Only three authors described basal achene size: Yatskievych (1999) states that they are "slightly larger" than terminal achenes, Smith (2002) stated a range from 1.7–2.5 mm long and 1.0–1.3 mm wide, and Schuyler (1969) published a photograph of one terminal and basal achene pair. While the photograph is the most useful representation of the appearance of basal achenes currently available in the published literature, neither the verbal nor the visual description is adequate to understand the

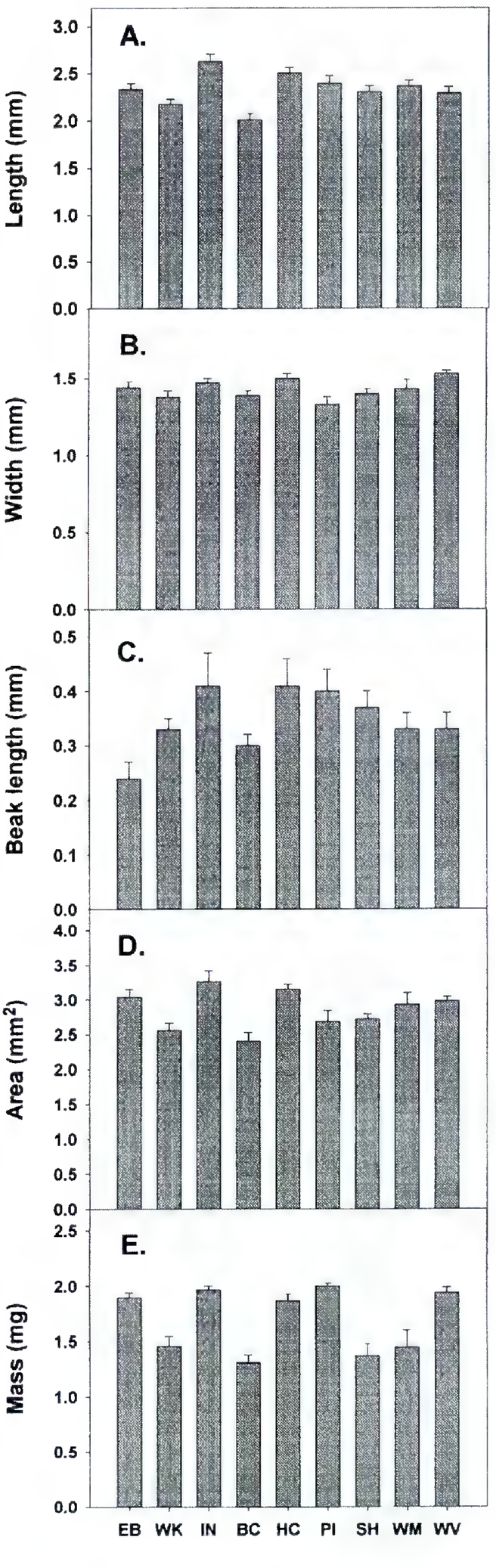


FIG. 5 A–E. A. Length, B. width, C. beak length, D. area, and E. mass of basal achenes of *Schoenoplectus hallii* from 9 populations. Each bar represents the mean ± SE of 15 measurements.

TABLE 5. Summary ANOVA statistics for basal achenes of *Schoenoplectus hallii* from nine population sites.

Character	Source of Variation	SS	df	MS	F	*P*
Length	Between groups	2.5755.929	8	0.322	5.537	<0.001
	Within populations		102	0.058		
Width	Between groups	0.4141.969	8	0.052	2.680	0.010
	Within populations		102	0.019		
Area	Between groups	0.3411.401	8	0.043	3.106	0.004
	Within populations		102	0.014		
Area	Between groups	7.246	8	0.906	5.416	<0.001
	Within populations	17.066	102	0.167		
Mass	Between groups	8.584	8	1.068	11.204	<0.001
	Within populations	9.727	102	0.096		

TABLE 6. Significant differences in mean length, width, mass and beak length of basal achenes among nine populations of *Schoenoplectus hallii*. All *P* values calculated by Bonferonni's t-test.

Length	*P*	Mass	*P*
BC vs IN	≤0.003	BC vs EB	<0.001
Vs HC	<0.001	vs IN	≤0.014
vs PI	<0.001	vs HC	<0.001
Width	*P*	vs PI	<0.001
PI vs WV	≤0.009	vs WV	<0.001
Beak	*P*	PI vs SH	<0.001
EB vs HC	≤0.006	vs WV	<0.001

magnitude and constancy of the differences between achene types, nor the potential of using size to separate achenes. Mean size and mass data, including values for the unusually wide terminal achenes at the HC population, indicate that basal achenes average 1.5× longer, 1.1× wider, 1.5× greater in area and 2.8× heavier than terminal achenes (Table 4).

Although data in the present study indicated that there was significant variation in morphology among basal achenes, they easily can be distinguished from terminal achenes, and at any site lacking *S. saximontanus* or *S. erectus* they can be identified easily to species. Except for the mixed populations in OK and KS, there are no known sites where *S. hallii* co-occurs with the species with which its basal achenes might easily be confused. Although we processed from 20–100 soil cores from each of the 12 sites to determine the potential seed bank for *S. hallii*, we did not find any mature achenes of any other species that resembled *S. hallii* basal achenes.

Various authors have noted that transverse or horizontal ridges are present on the surface of achenes of *S. hallii* (Beetle 1942; Gleason & Cronquist 1963; Magrath 2002; Radford et al. 1964; Schuyler 1969; Mohlenbrock 1976; Kolstad 1986; Robertson et al. 1994; Rolfsmeier 1995; Yatskievych 1999). Our observations confirm the presence of prominent horizontal ridges on all terminal achenes examined; however, they are absent or incomplete on basal achenes, which have conspicuous vertical ridges. Although prominent horizontal ridges are limited to terminal achenes, this character is universally attributed to achenes in *S. hallii*.

Cross-sectional shape is often used to separate terminal achenes in *S. hallii*, described as "unequally biconvex in cross section" by Yatskievych (1999), from terminal achenes in

S. saximontanus, which have a distinctly 3-angled shape (Yatskievych 1999). Our study corroborates the general regularity of this feature in *S. hallii* throughout the 12 populations studied; however, as is the case with basal achenes, there are exceptions (Fig. 2C).

Because all published studies of *S. hallii* are confined to the species' taxonomy or occurrence (distribution and rarity or abundance in various regions), which required no large-scale seed collection, no authors have suggested any methods for separating achenes from bulk soil samples. The results of our study indicate that it is possible to separate terminal and basal achenes from soil samples using a series of soil sieves. Surface litter and a large soil fraction can be separated from achenes by using sieves of various sizes, depending upon the type of soil and the nature of the litter. For example, if a sample contains considerable extraneous organic matter, one can use a #5 sieve to remove litter, a #14 sieve to remove coarse particles if the soil is sandy, and then sift the soil through sieves #16, #18 and #20 to separate achenes by type. The majority of the basal achenes will not pass through the #16 sieve, and the few that do are always retained by the #18 sieve. A small proportion of the terminal achenes remain in the #18 sieve (as was the case with many of HC achenes) with the majority of achenes passing through into the #20 sieve. In our study, none of the achenes passed through the #20 sieve into the next sieve. If the soil is predominantly silt or fine loam, all soil passes through the #20, which facilitates the final collection and counting of achenes. If soil is composed of coarse sand, larger grains can be filtered out of the sample using the #14 sieve and finer particles of sand will pass through the #18 sieve; however, it is impossible to remove all coarse sand from achenes using sieves. Final separation of achenes from sand must be done manually. Although this final process requires some manual separation of achenes and soil using a dissecting microscope, the processing of bulk samples of soil for seeds is greatly facilitated using the graduated sieve method described. For future seed bank and germination studies requiring large numbers of achenes, this method will be useful. Based on assumptions of a long-lived seed bank, populations of *S. hallii* are often listed as "extant" if plants existed at the site during the previous 25 years (McKenzie 1998); therefore, seed bank studies may be essential to the correct assessment of the species' status.

Unlike terminal flowers, which have uniformly bifid styles, with the exception of the single 4-parted style from HC, basal flowers have trifid styles as shown in Fig. 2A and 3B–D. Most references to the number of divisions present in *S. hallii* styles indicate the presence of bifid styles (Steyermark 1963; Kolstad 1986; Rolfsmeier 1995; Smith 2002), with only Yatskievych (1999) noting "stigmas 2 (rarely 3 in basal spikelets)." Although all basal styles had trifid branching, this only became apparent in some cases when the styles were floated on a film of water, which allowed shorter style lobes to separate from the main branch of the style (Fig. 3–D). Styles of basal flowers, as previously indicated by Yatskievych (1999), are longer than those of terminal flowers (Table 4, Figs. 2A and 3A–D). Our data indicate that this difference is significant (statistics not shown, see Table 4 for mean values) with no overlap in size between the two style types.

In summary, significant variation in achene size and shape occurs within and among populations; identification and separation of terminal and basal achenes can be accomplished rapidly using a series of sieves; transverse ridging is not a regular or prominent feature of basal achenes; and in the vast majority of cases, a bifid style is a consistent character in the terminal flowers (we noted one exception). All basal styles examined were trifid. Data from this study provide visual and quantitative information that will facilitate the collection and identification of terminal and basal achenes of *S. hallii* from

plants, soil and wildlife and contribute to an accurate assessment of the species' conservation status.

ACKNOWLEDGMENTS

We thank the Missouri Department of Conservation, U.S. Fish and Wildlife Service and the Graduate School at Southern Illinois University, Edwardsville, IL, for financial support for this study. We are also grateful to a number of colleagues and students who helped in making this study possible: Chairo Shaffer, Dan Free, Bethany Meinardii, Josh Knolhoff and Rasheda Johnson who helped with achene collection and identification; Xiaowen Wang who helped measure achenes; Michael Homoya who provided achenes and plants from Indiana, C.C. Baskin, J.M. Baskin and E. W. Chester for collecting soil samples in Kentucky; reviewers Paul McKenzie, Larry Magrath and Galen Smith for their helpful comments; and Paul McKenzie for comic relief and help in field collection of plants and achenes.

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Book Reviews

David A. Sleper and John M. Poehlman. 2006. **Breeding Field Crops, Fifth Edition.** (ISBN 0-8138-2428-1, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** 515-292-0140, 515-292-3348 fax 1-800-862-6657, www.blackwellprofessional.com, orders@ames.blackwellpublishing.com,). $84.99, 392 pp., 448 b/w illustrations and photographs, 7" × 10".

This book is intended for beginning students of plant breeding as well as more advanced students and professional plant breeders. The first edition was published in 1959, "and since that time it has been one of the most popular plant breeding textbooks used throughout the world." One of the most significant developments in plant breeding since edition 4 (1995) has been incorporation of "translational genomics"—using "tools developed by molecular biologists, such as DNA markers, ... to map and tag important plants traits on the genomes of many of our crop plants."

Section I: What is Plant Breeding?
Section II: The Genetic Basis of Plant Breeding
Section III: Tools of the Plant Breeder (including chromosome number, mutation, fertility-regulating mechanisms, biotechnology)
Section IV: Methods in Plant Breeding
Section V: Germplasm Resources for Breeding Crop Plants
Sections VI through **IX:** Applications: Breeding field crops that are self-pollinated or vegetatively propagated; Utilizing hybrid and other miscellaneous breeding procedures
Section X: Maintenance and Seed Production of Improved Cultivars

—Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.

Robin White. 2006. **Daphnes: A Practical Guide for Gardeners.** (ISBN 0-88192-752-X, 978-0-88192-752-8, hbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax.). $34.95, 232 pp., color photos, 7" × 9".

The book is written from the author's 30 years of experience in propagating and growing daphnes, both as a commercial horticulturalist and as a home gardener (in his "daphnetum") in southern England. It is arranged in seven chapters: History, Taxonomy, and Morphology; *Daphne* Species; *Daphne* Hybrids; Propagation; Cultivation; Pests and Diseases; and Garden Use. Nearly half of White's book is given to discussion of 36 species, each with interesting comments on cultivation and description and with subheadings for "propagation" and "botanical variants" and/or "named clones." Various cultivars of the two North American adventives, *D. laureola* L. (native to North Africa and Europe) and *D. mezereum* L. (native to Central Asia and Europe), are included. Excellent color photos of many of the species and variants accompany the text.

Daphne includes 70 species (monographed by J. Halda in 2001) mainly found in Europe and temperate and subtropical Asia. They are deciduous and evergreen shrubs, from prostrate and mat-forming to erect and up to 5 meters tall. Flowers are 4-petaled and vary from creamy white to pink, purple, lilac, yellow, and green. The author notes that "if they are given the right environment and treatment, daphnes are long-lived plants worthy of a place in every garden. What is true is that daphnes are unforgiving of mismanagement ... [but] ... To most of us, growing daphnes is a challenge which makes success that much sweeter."—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

ANNOTATED CHECKLIST OF THE VASCULAR FLORA OF THE LANCE ROSIER UNIT OF THE BIG THICKET NATIONAL PRESERVE, HARDIN COUNTY, TEXAS

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ABSTRACT

An annotated, vouchered checklist is provided of the vascular plant taxa of the 10,100 hectare Lance Rosier Unit, Big Thicket National Preserve, Hardin County, in southeastern Texas. Documented for the unit are 694 taxa of which 71 (10%) are exotics.

RESUMEN

Se aporta un catálogo con comentarios y pliegos testigo de los táxones de plantas vasculares de las 10,100 hectáreas de la reserva Lance Rosier Unit, Big Thicket National Preserve, del condado de Hardin, en el sureste de Texas. Se documentan para la unidad 694 táxones de los que 71 (10%) son exóticos.

INTRODUCTION

This is the fourth part of an inventory, based upon available voucher specimens, of the vascular flora of the Big Thicket National Preserve, in southeastern Texas. In three previous papers, we provided an annotated checklist of the Hickory Creek, Turkey Creek, and Big Sandy Creek units (MacRoberts et al. 2002; Brown et al. 2005; Brown et al. 2006). In this paper, we provide an annotated checklist of the Lance Rosier Unit.

SITE AND METHODS

The Big Thicket is located mostly within the longleaf pine region of the West Gulf Coastal Plain in southeastern Texas (Parks & Cory 1936; McLeod 1971; Harcombe & Marks 1979; Marks & Harcombe 1981; Harcombe et al. 1993). The Big Thicket National Preserve consists of 12 units scattered over seven Texas counties. The units range from 222 to 10,100 hectares and total about 34,000 hectares (Peacock 1994). The Lance Rosier Unit consists of 10,100 hectares and is located in southern Hardin County (Fig. 1). It is relatively flat with poor drainage over most of the area. Elevation ranges from about 14 to 30 meters. The Little Pine Island Bayou runs through its western and southern sections. The Lance

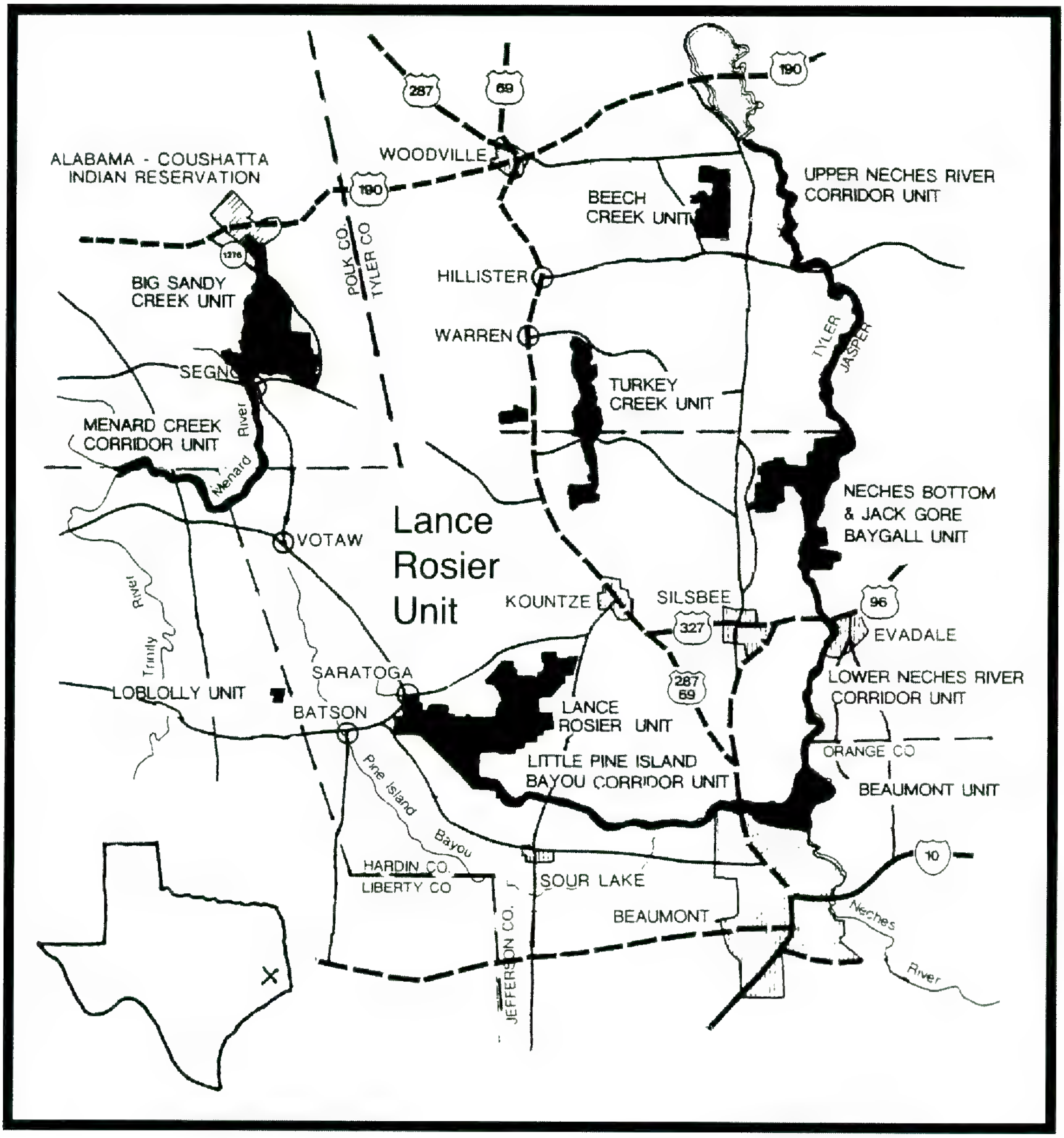


FIG. 1. Location of the Lance Rosier Unit, Big Thicket National Preserve, Texas.

Rosier Unit was chosen for inclusion in the Big Thicket National Preserve because of its wide range of plant communities (Ajilvsgi 1979; Harcombe & Marks 1979; Watson 1979; Harcombe & Marks 1981; MacRoberts & MacRoberts 1998). It is dominated by lower-slope hardwood pine forest and wetland pine savanna, but also has flatland hardwood forest, floodplain hardwood forest, and baygall thicket (Harcombe & Marks 1979; Marks & Harcombe 1981). Mima mounds are common in the wetland pine savanna sections. Fire suppression over the past 30 years has resulted in extensive midstory development and shading out of herbaceous vegetation. A map of community types can be found in Harcombe and Marks (1979), and details regarding soils, topography, and climate can be found in Deshotels (1978), Watson (1979, 1982), Harcombe and Marks (1979), and Marks and Harcombe (1981).

Like all units of the Big Thicket National Preserve, the Lance Rosier Unit had not previously been the subject of a detailed floristic inventory.

Larry Brown collected about 750 specimens during 15 field days beginning May 23, 2004 and ending May 14, 2006.

The MacRoberts' collected 73 specimens during a study of wetland pine savanna in 1997 and 1998. Stanley Jones collected 317 specimens during 2002 and 2003. Geraldine Watson collected 87 specimens over several years in the late 1970s and early 1980s. Other collectors (Sandi Elsik, Warren Pruess, William Carr, Paul Harcombe, Donna Streng, C. Liu, and Eric Keith) gathered 198 specimens. A search of the on line TAMU herbarium consortium database found some collections at TEX which were annotated and added to the list.

Because our purpose is to produce a list of taxa known to occur on the Lance Rosier Unit, a vouchered specimen was considered to be the only evidence acceptable for inclusion in the list. In all, more than 1331 herbarium specimens form the data for this report. All specimens at Rice University have been annotated by Larry Brown. A complete set of these mounted specimens are to be donated to TAES, the Tracy Herbarium, at Texas A&M University. Duplicates collections will be distributed to other herbaria.

In most cases, nomenclature follows Jones et al. (1997) and Kartesz and Meacham (1999). For *Dichanthelium* we followed a pre-publication key in Diggs et al. (2006). Some recent literature sources were followed, especially some nomenclature in the published Flora of North America volumes. In cases of multiple collections, no more than four are listed for each taxon.

RESULTS

The following is an annotated list of the Lance Rosier Unit taxa. Abbreviations used are given below.

CL = C. Liu. His specimens are at Rice University.
DS = Donna Streng. Her collections are at Rice University.
DW = David Wolf. His one specimen is at TEX.
EK = Eric Keith. His collections are at Rice University.
GW = Geraldine Watson. Her specimens are at Rice University.
LB = Larry Brown. His specimens are at Rice University except for those few at SBSC.
MM = Barbara and Michael MacRoberts. Their specimens are at TEX, VDB, and BRIT. Also, as noted, one or two are at SBSC.
PH = Paul Harcombe. His collections are at Rice University
RJ = Ray Jordan. His collections are at TEX.
SEWP = Sandra Elsik and Warren Pruess. Their specimens are at Rice University.
SJ = Stanley Jones. His specimens are at Rice University.
WRC = William Carr. His specimens are at TEX.
* = exotic
+ = see note at end of list.

ACANTHACEAE

Justicia ovata (Walter) Lindau var. *Lanceolada* (Chapm.) R.W. Long, LB 30165; SEEKWP 3100

Ruellia caroliniensis (J.F.Gmel.) Steud, LB 30574; SEEKWP 3098

Ruellia humilis Nutt., SJ 14095, 14069; LB 30030

ACERACEAE

Acer rubrum L., SJSEWP, 15042, 15041; LB 30287

AGAVACEAE

Manfreda virginica (L.) Salisb. ex Rose, LB 31083

ALISMATACEAE

Sagittaria papillosa Buchenau, LB 29375, 29363, 30041; SJ 13757

Sagittaria platyphylla (Engelm.) J.G. Sm., LB 30170

ANACARDIACEAE

Rhus copallinum L., SJ 13762; LB 29863

Toxicodendron radicans (L.) Kuntze, LB 29837, SEWP 3053

ANNONACEAE

Asimina parviflora (Michx.) Dunal, SJ 13806; LB 31181

APIACEAE

Centella erecta (L.f.) Fernald, SJ 17780

Chaerophyllum tainturieri Hook. var. *tainturieri*, LB 30407; SJSEWP 15085

Cicuta maculata L., LB 30666; SJ 14091

**Cyclospermum leptophyllum* (Pers.) Sprague ex Britton &Wilson, LB 30596

Eryngium integrifolium Walter, LB 30231, 30101, 30596, 30697

Eryngium prostratum Nutt. ex DC, LB 30587; SJ 13906

Hydrocotyle verticillata Thunb., LB 30069

Oxypolis filiformis (Walter) Britton, LB 30733, 30016; MM 3478; WRC 17231

Ptilimnium capillaceum (Michx.) Raf., LB 29344; SEEKWP 3094

Ptilimnium costatum (Elliott) Raf., LB 30254

Sanicula canadensis L., LB 29915; SJ 14073; GW 3102

APOCYNACEAE

Trachelospermum difforme (Walter) A. Gray, LB 30246

AQUIFOLIACEAE

Ilex ambigua (Michx.) Torr., SJ 14048

Ilex coriacea (Pursh) Chapm., LB 30678, 30111a; SJ 13866,13773

Ilex decidua Walter, LB 29329; SJ 14242

Ilex longipes Chapman, LB 31056

Ilex opaca Soland., LB 29838; SJ 13776

Ilex vomitoria Aiton, LB 29983; SJ 13759

ARACEAE

Arisaema triphyllum (L.) Schott, SJ 13843

ARALIACEAE

Aralia spinosa L., LB 29854a

ARECACEAE

Sabal minor (Jacq.) Pers., SJ 14022; LB 30037

ARISTOLOCHIACEAE

Aristolochia serpentaria L., GW 156-2

ASCLEPIADACEAE

Asclepias longifolia Michx. subsp. *longifolia*, SJ 13992; LB 29379; MM 3874

Asclepias perennis Walter, LB 29929; SEEKWP 3104

Asclepias variegata L., LB 30055

Matelea gonocarpos (Walter) Shinners, LB 30592, 29862; SJ 14243

ASPLENIACEAE

Asplenium platyneuron (L.) Britton, Sterns & Poggenb., LB 29910; SJ 13848, 14178

ASTERACEAE

Acmella oppositifolia (Lamarck) R.J. Jansen var. *repens* (Walter) R.J. Jansen, LB 29919; SJ 14245

Ageratina altissima (L.) King & H.E. Rob., GW 2006

Ambrosia artemisiifolia L., LB 30044, 30872

Ambrosia psilostachya DC., WP 068; LB 30872, 30891

Ambrosia trifida L., LB 30066

Amphiachyris dracunculoides (DC.) Nutt., GW 3142

Arnoglossum ovatum (Walter) H.E. Rob., SEEKWP 3115; SJ 14513

Baccharis halimifolia L., GW 3150

Bidens aristosa (Michx.) Britton, LB 30141, 29397; SJ 14084; GW 3083

Bidens bipinnata L., GW 3136, 3149

Bidens frondosa L., LB 30224, 30213; GW 1742

Boltonia diffusa Elliott, LB 29998, 30018; MM 3652; SJ 14027

Chaptalia tomentosa Vent., MM 3733; LB 31058

Chloracantha spinosa (Benth.) Nesom, GW 3409

Cirsium horridulum Michx., LB 30391, 30617; SEWP 3052

Conoclinium coelestinum (L.) DC., SJ 14088

Conyza canadensis (L.) Cronquist var. *canadensis*, SJSEWP 15090

Conyza canadensis (L.) Cronquist var. *glabrata* (A. Gray) Cronquist, LB 30068

+Coreopsis gladiata Walter, LB 30229, 30901; MM 3662; CL 901127

+Echinacea pallida (Nutt.) Nutt. var. *sanguinea* (Nutt.) Gandhi & R.D. Thomas, SJ 14098

Eclipta prostrata (L.) L., LB 30158

Elephantopus carolinianus Raeusch., LB 30053

Elephantopus nudatus A. Gray, LB 30239, 30772; GW 2412

Elephantopus tomentosus L., LB 30060, 30050; 30049; WP 069a

Erechtites hieraciifolia (L.) Raf. ex DC., LB 29940; SJ 13890

Erigeron philadelphicus L., SJSEWP 15093

Erigeron procumbens (Houst. ex Mill.) Nesom, WP 088

Erigeron strigosus Muhl. ex Willd., SJ 13819

Erigeron tenuis Torr. & A. Gray, SEWP 3073

Eupatorium capillifolium (Small) Lam., LB 30193; WP 070

Eupatorium hyssopifolium L., LB 30735, 30257; RJ s.n.

Eupatorium leucolepis (DC.) Torr. & A. Gray, MM 3641

Eupatorium mohrii Greene, LB 30897; PH 901146

Eupatorium perfoliatum L., LB 30635, 29368

Eupatorium rotundifolium L., LB 29361

+Eupatorium semiserratum DC., LB 30166, 29979; RJ s.n.

Eupatorium serotinum Michx., LB 30142; RJ s.n.

Eurybia hemispherica (Alexander) Nesom, LB 30120

Euthamia leptocephala (Torr. & A. Gray) Greene ex Porter & Britton, LB 29847, 30143; GW 3139

Gaillardia pulchella Foug. var. *pulchella*, LB 30625, 29854; SJ 14232
Gamochaeta coarctata (Willd.) Kerguelen, LB 30623, 30397
Gamochaeta pensylvanica (Willd.) Cabrera, LB 30601, 31229
Gamochaeta purpurea (L.) Cabrera, LB 30398, 30590; SEWP 3058; SJ 14264
Helenium amarum (Raf.) H. Rock var. *amarum*, LB 29887. 29878; SJSEWP 15048
Helenium drummondii H. Rock, SJ 13787; MM 3784, 3786
Helenium flexuosum Raf., LB 29957, 30059; SJ 14170; GW 3101
Helianthus angustifolium L., MM 3735; CL 901125
Heterotheca subaxillaris (Lam.) Britton & Rusby, LB 30194, SJ 14240
Hieracium gronovii L., LB 30720
**Hypochaeris microcephala* (Sch. Bip.) Cabrera var. *albiflora* (Kuntze) Cabrera, SJ 13932
Iva angustifolia Nutt. ex DC., LB 30071
Iva annua L., WP 062; LB 30249, 30249a
Krigia wrightii (A. Gray) K.L. Chambers ex K.J. Kim, LB 31165
Liatris acidota Engelm. & A. Gray, LB 29996; WRC 17233; MM 4005; SJ 14295
Liatris pycnostachya Michx., MM 3648b; LB 30238, 30232
Marshallia graminifolia (Walter) Small L.E. Watson, LB 30008; MM 3378; WRC 10838
Mikania scandens (L.) Willd., LB 30149, 29976
Pityopsis graminifolia (Michx.) Nutt., LB 30118; WP 059
+*Pluchea baccharis* (Mill.) Pruski, LB 29871, 30692; WRC 17707
Pluchea camphorata (L.) DC., LB 30183, 30058
Pluchea foetida (L.) DC., LB 29848; SJ 14511
Pseudognaphalium obtusifolium (L.) Hillard & Burtt, LB 30076
Pyrrhopappus carolinianus (Walter) DC., SEEKWP 3074; LB 29864, 29376
Pyrrhopappus pauciflorus (D. Don) DC., GW 2004; LB 31158
Rudbeckia hirta L., LB 30652
Rudbeckia texana (Perdue) P.Cox & Urbatsch, LB 30582; SEEKWP 3106
Silphium gracile A. Gray, CL 901124
Smallanthus uvedalia (L.) Mack. ex Small, LB 31054
Solidago canadensis L. var *scabra* Torr. & A. Gray, LB 30139
Solidago odora Aiton var. *odora*, LB 30255, 30221; WP 061
Solidago rugosa Mill. subsp. *asper* (Aiton) Cronquist, LB 29988
Solidago rugosa Mill. subsp. *rugosa*, LB 30140, 30884
Solidago sempervirens L. var. *mexicana* (L.) Fernald,„LB 30191; GW 3462
Solidago tortifolia Elliott, RJ s.n.
**Soliva sessilis* Ruiz & Pavon., SEEKWP 3077; LB 31168
**+Soliva anthemifolia* (Jussieu) Sweet, LB 31233
**Sonchus asper* (L.) Hill, SJSEWP 15092; LB 31160
Symphyotrichum divaricatum (Nutt.) Nesom, GW 1574; LB 30215
Symphyotrichum dumosum (L.) Nesom, LB 30235, 30240; SJ 14257; MM 3648
Symphyotrichum lateriflorum (L.) A. & D. Love, WP 058
Symphyotrichum racemosum (Elliott) Nesom, LB 30244, 30881, 30880
Vernonia missurica Raf., LB 29833, *30889*
Xanthium strumarium L., LB 29912
**Youngia japonica* (L.) DC., SJ 14021; LB 31049

AZOLLACEAE
Azolla caroliniana Willd., LB 30902

BERBERIDACEAE
Podophyllum peltatum L., GW 3048

BETULACEAE
Carpinus caroliniana Walter, SJ 14176
Ostrya virginiana (Mill.) K. Koch, SJ 14114, 14173; LB 30093

BIGNONIACEAE
Bignonia capreolata L., LB 29328, 30091; WP 091
Campsis radicans (L.) Seem. ex Bureau, LB 29832; SJ 14250
Catalpa bignonioides Walter, LB 29340

BLECHNACEAE
Woodwardia areolata (L.) T. Moore, LB 30777
Woodwardia virginica (L.) Sm., LB 29396

BORAGINACEAE
Heliotropium procumbens Mill., LB 30160, 30672
Myosotis macrosperma Engelm., SEWP 3063

BRASSICACEAE
Cardamine bulbosa (Schreb. Ex Mull.) Britton, Sterns, Poggenb., GW 3049
**Cardamine debilis* D. Don, LB 30292a
**Cardamine hirsuta* L., LB 30292
Lepidium virginicum L., LB 30603

BROMELIACEAE
Tillandsia usneoides (L.) L., LB 29904; SJ 13845

BUDDLEJACEAE
Polypremum procumbens L., LB 29896

BURMANNIACEAE
Burmannia capitata (J.F. Gmel.) Mart., LB 30107

CACTACEAE
Opuntia stricta (Haw.)Haw., GW 1639

CALLITRICHACEAE
Callitriche heterophylla Pursh, SJSEWP 15076
Callitriche peploides Nutt., SJSEWP 3107; LB 31228

CAMPANULACEAE
Lobelia cardinalis L., LB 30167

Lobelia flaccidifolia Small, LB 30636, 29362; MM 3920
Lobelia puberula Michx., SJ 14261; LB 30241
Lobelia reverchonii B.L. Turner, LB 30230; PH 901144
Triodanis biflora (Ruiz & Pavon) Greene, LB 30604
Triodanis perfoliata (L.) Nieuwl., GW 3061

CAPRIFOLIACEAE

**Lonicera japonica* Thunb., SEWP 3065
Lonicera sempervirens L., SJ 13929
Sambucus nigra L. subsp. *canadensis* (L.) R. Bolli, LB 30390; SEEKWP 3105
Viburnum dentatum L., SEEKWP 3078; LB 29861a, 29853
Viburnum nudum L. var. *nudum*, SJ 13998; LB 29401, 30033

CARYOPHYLLACEAE

**Cerastium glomeratum* Thuill., SJSEWP 15066
Sagina decumbens (Elliott) Torr. & A. Gray, LB 30400; SEEKWP 3108
**Stellaria media* (L.) Vill., SJSEWP 15063

CISTACEAE

+*Lechea minor* L., LB 30003

COMMELINACEAE

Commelina virginica L., LB 30153

CONVOLVULACEAE

Dichondra carolinensis Michx., LB 30075; SJ 13849
Evolvulus sericeus Sw., LB 30121
Ipomoea coccinea L., GW 3154
Ipomoea cordatotriloba Dennst. var. *cordatotriloba*, LB 29867; SJ 14235

CORNACEAE

Cornus florida L., SJSEWP 15043; LB 31047
Cornus foemina Mill., LB 29938; SJ 13758
Nyssa aquatica L., SJ 14122
Nyssa biflora Walter, LB 29407; WRC 17365
Nyssa sylvatica Marshall., LB 29336, 29978

CRASSULACEAE

Penthorum sedoides L., LB 30671

CUCURBITACEAE

Cayaponia quinqueloba (Raf.) Shinners, SJ 14515

CUPRESSACEAE

Taxodium distichum (L.) L. C. Rich., LB 30207, 29917; SEEKWP 3099

CYPERACEAE

Carex abscondita Mack., SJ 13851
Carex albicans Willd. ex Spreng. subsp. *australis* (Bailey) J.H. Rettig, SEEKWP 3097; LB 30291
Carex annectens E.P. Bicknell, LB 30382
Carex basiantha Steud., SJ 13696; LB 30610
Carex blanda Dewey, SJ 13916
Carex bulbostylis Mack., LB 31163
Carex caroliniana Schwein, LB 30612, 30575
Carex cherokeensis Schwein., SJSEWP 15049
Carex complanata Torr. & Hook., LB 30381, 29330; SJ 14552, 13864
Carex crebriflora Wieg., SJ 14553, 13597
Carex crus-corvi Shuttl. ex Kunze, SEEKWP 3102
Carex debilis Michx. var. *debilis*, SJ 13860; LB 31075
Carex digitalis Willd. var. *asymetrica* Fernald, SJ 13852
Carex flaccosperma Dewey, SJ 13803; LB 30388a; SEWP 3054
Carex frankii Kunth, LB 30598; SEEKWP 3090
Carex gigantea Rudge, SJ 14177, 14020
Carex glaucescens Elliott, CL 901119; SJ 14162
Carex intumescens Rudge, SEEKWP 3112; SJ 13857; LB 31077
Carex joorii Bailey, LB 30781; SJ 14016
Carex leavenworthii Dewey, SJSEWP 15079
Carex longii Mack., SJ 13863; LB 30581, 29341
Carex louisianica Bailey, LB 29845
Carex oxylepis Torr. & Hook. var. *oxylepis*,, SJ 13917
Carex retroflexa Muhl. ex Willd., LB 30406, 30602; SJSEWP 15080
Carex striatula Michx., SJ 13804
Carex tetrastachya Scheele, SJ 13862
Carex texensis Bailey, LB 30395; SJSEWP 15056
Carex triangularis Boeck., SJ 13908; LB 30578
Carex tribuloides Wahlenb. var. *sangamonensis* Clokey, LB 30607; SEEKWP 3088
Carex verrucosa Muhl., SJ 14024
Carex vulpinoidea Michx., LB 30383
Cladium mariscus J. Pohl subsp *jamaicense* (Crantz) Kukenth., LB 30898, 19238b (SBSC), 19421 (SBSC); SJ 14423
Cyperus acuminatus Torr. & Hook. ex Torr., LB 29891a
Cyperus articulatus L., LB 30154, SJ 14058
**Cyperus entrerianus* Boeckl., LB 29914
Cyperus erythrorhizos Muhl., LB 30151
Cyperus haspan L., LB 30262, 29947; SJ 14041
Cyperus ochraceus Vahl, LB 30885
Cyperus odoratus L., LB 30712
Cyperus oxylepis Nees ex Steud., SJ 14060, 14260
Cyperus polystachyos Rottb., SJ 14059; GW 3165
Cyperus pseudovegetus Steud., SJ 13867, 14076, 14010
Cyperus retrorsus Chapm., SJ 14271
Cyperus strigosus L., SJ 14277
Cyperus surinamensis Rottb., SJ 14267
Cyperus thyriflorus Jungh., LB 29905; SJ 14174; SEEKWP
Cyperus virens Michx., SJ 13896; LB 29339
Eleocharis baldwinii (Torr.) Chapman, LB 30387, 30163
Eleocharis geniculata (L.) Roemer & J.S. Schultes, LB 30212, 29946
Eleocharis microcarpa Torr., LB 30654, 30643; SJ 14550; MM 3852
Eleocharis montana Roem. & Schult., LB 30890
Eleocharis montevidensis Kunth, LB 29333; SJ 14070
Eleocharis tuberculosa R. Br., MM 3858; LB 30216, 29961; WRC 17230

Fimbristylis autumnalis Roem. & Schult., LB 30157, 30036; GW 3166b
**Fimbristylis miliacea* (L.) Vahl, LB 30157a, 29989
Fimbristylis puberula Vahl var. *puberula* Vahl, SJ 14101; LB 31182
Fuirena breviseta (Cov.) Cov., LB 30727, 29948; MM 3480; WRC 17696; SJ 14110
Fuirena bushii Kral, LB 29393, 30010, 19239; SJ 14296
Isolepis carinata Hook. & Arn. ex Torr., LB 30409
Kyllinga brevifolia Rottb., LB 30087
Kyllinga odorata Vahl, SJ 14268
Kyllinga pumila Michx., LB 30263
Rhynchospora caduca Elliott, MM 3479b , 3540 LB 29883a
Rhynchospora colorata (L.) H. Pfeiffer, LB 29880, 29417; SJ 13770
Rhynchospora corniculata (Lam.) A. Gray, LB 29369
Rhynchospora divergens Chapm., LB 29410
Rhynchospora elliottii A. Dietr., LB 19280; MM 3927, 3948; SJ 14081
Rhynchospora fascicularis (Michx.) Vahl, LB 30217
Rhynchospora filifolia A. Gray, LB 30658, 30020; MM 3485,3851
Rhynchospora globularis (Chapm.) Small, var. *globularis* LB 15998; MM 3864, 3938
Rhynchospora globularis (Chapm.) Small var. *pinetorum* (Britton & Small ex Small) Gale, SJ 14074
Rhynchospora glomerata (L.) Vahl, LB 30260; MM 3646; WRC 17703a; SJ 14163
Rhynchospora gracilenta A. Gray, MM 3844c; LB 30645, 30021; SJ 14613
Rhynchospora inexpansa (Michx.) Vahl, LB 30079, 30073; MM 3541; SJ 14164
Rhynchospora latifolia (Baldw. ex Elliott) Thomas, SJ 14077; MM 3940
Rhynchospora mixta Britton, LB 29895; SJ 14106
Rhynchospora perplexa Chapm. ex M. A. Curt. LB 30633, 30632, 30629, 29354
Rhynchospora plumosa Elliott, LB 30236; WRC 17355; MM 3488b; SJ 13936
Rhynchospora pusilla Chapm. ex M.A. Curtis, LB 30665, 30024a, 20417; MM 3479
Rhynchospora rariflora Elliott, LB 30630, 29383, 29353; MM 3867
Rhynchospora recognita (Gale) Kral, LB 29416, 30647, 29390; SJ 14080
Scirpus cyperinus Palla, LB 30696
Scleria georgiana Core, MM 3386 (SBSC), 3488; SJ 13768; LB 15999 (SBSC)
Scleria oligantha Michx., LB 30608, 30576; SEEKWP 3110
Sclera pauciflora Muhl. ex Willd., LB 30015; SJ 13797
Scleria reticularis Michx., MM 6667
Scleria triglomerata Michx., LB 30649, 29355, 30061; SEEKWP 3111

CYRILLACEAE

Cyrilla racemiflora L., LB 30006; SJ 14089

DENNSTAEDTIACEAE

Pteridium aquilinum (L.) Kuhn, WP 090; LB 30045

DROSERACEAE

Drosera brevifolia Pursh, SJ 13769; MM 3781
Drosera capillaris Poir., LB 29418; SJ 14043; MM 3860; GW 3064

DRYOPTERIDACEAE

Polystichum acrostichoides (Michx.) Schott, LB 30614, 30056, 29984
Woodsia obtusa (Spreng.) Torr. subsp *obtusa*, SJ 14018

EBENACEAE

Diospyros virginiana L., LB 29937a; SJ 14051, 14248

ERICACEAE

Rhododendron canescens (Michx.) Sweet, SJSEWP 15044; LB 31080
Rhododendron viscosum (L.) Torr., SJ 14119
Vaccinium arboreum Marshall, SJ 13785; LB 29953, 30280
Vaccinium corymbosum L., LB 30412, 30223; SJ 13799, 14167

ERIOCAULACEAE

Eriocaulon decangulare L., LB 29398; SJ 14156; WRC 17697; GW 3100
Lachnocaulon anceps Morong, LB 29415; SJ 13774

EUPHORBIACEAE

Acalypha gracilens A. Gray, GW 3138; LB 30210, 30715, 30077
Acalypha virginica L., SJ 14165
**Caperonia palustris* (L.) St.-Hil., GW 3138
Chamaesyce cordifolia (Elliott) Small, SJ 14198
Chamaesyce humistrata (Engelm.) Small GW 3162
Chamaesyce maculata (L.) Small, LB 30201, 29935, 30713
Chamaesyce nutans (Lag.) Small, GW 3106, 3168; LB 30195, 30202
Croton capitatus Michx., WP 069; LB 29921
Croton glandulosus L. var. *glandulosus* Muell.-Arg. LB 30718, 29855
Croton monanthogynus Michx., LB 30886
Euphorbia corollata L., LB 30732a, 30252, 30099
Phyllanthus caroliniensis Walter, LB 30896, 30198, GW 3085
**Phyllanthus urinaria* L., LB 29868; GW 3105, 3140
**Triadica sebifera* (L.) Small, SEEKWP 3096
**Vernicia fordii* (Hemsl.) Airy-Shaw, SEEKWP 3109; LB 30090

FABACEAE

**Albizia julibrissin* Durazz., SEEKWP 3083; LB 30248, 30051
Amorpha fruticosa L., . LB 30618, 29926
Baptisia bracteata Muhl. ex Elliott var. *laevicaulis* (A. Gray ex Canby) Isley, LB 31085
Centrosema virginianum (L.) Benth., LB 29851; GW 3145

Cercis canadensis L. var. *canadensis*, SJSEWP 15054
Chamaecrista fasciculata (Michx.) Greene, LB 29849
Chamaecrista nictitans (L.) Moench, GW 3137
Desmanthus illinoensis Mac. Mill., LB 30667
Desmodium glabellum (Michx.) DC., LB 30721
Desmodium laevigatum (Nutt.) DC., GW 3144
Desmodium paniculatum DC., LB 30185, 30043; SJ 14071; GW 3152
Erythrina herbacea L., LB 30615
Galactia volubilis (L.) Britton, LB 29860; GW 3148
Gleditsia tricanthos L., GW 2717
Glottidium vesicarium (Jacq.) Harper, LB 30716, 29943, 29925
Lespedeza virginica (L.) Britton, GW N20
Lupinus subcarnosus Hook., GW 3074; LB 31052
**Medicago lupulina* L., LB 30408; SEEKWP 3081
**Medicago polymorpha* L., LB 30286
Mimosa hystricina (Small ex Britton & Rose) B.L. Turner, MM 3660
**Melilotus indicus* (L.) All., SEWP 3048; LB 31048
Mimosa hystricina (Small ex Britton & Rose) B.L. Turner, LB 29387, 29373; MM 3660; SJ 13779
Mimosa strigillosa Torr. & A. Gray, LB 30714
Neptunia pubescens Benth., LB 31238
Senna obtusifolia (L.) Irwin & Barneby, LB 29918
Sesbania drummondii (Rydb.) Cory, SEEKWP 3103; LB 30181, 29927
Sesbania herbacea (Mill.) McVaugh, LB 30710; WP 065
Strophostyles umbellata (Muhl. ex Willd.) Britton, LB 30057; SJ 14086, 14263
Tephrosia onobrychoides Nutt., SJ 14298; LB 29999
**Trifolium campestre* Schreb., SJSEWP 15050
**Trifolium dubium* Sibthrop, LB 30403
**Trifolium repens* L., SEWP 3062; SJSEWP 15096
**Vicia hirsuta* (L.) S.F. Gray, LB 30402, 31053; SEWP 3067
Vicia ludoviciana Nutt. subsp. *ludoviciana*, GW 3073; LB 31051
Vicia minutiflora D. Dietr., SJSEWP 15091
**Vicia sativa* L. subsp. *nigra* (L.) Ehrh., SEWP 3066
**Vicia tetrasperma* LB 30620
Wisteria frutescens (L.) Poir., LB 30619

FAGACEAE

Castanea pumila (L.) Mill., SEEKWP 3116; SJ 13784
Fagus grandifolia Ehrh., WP 178; LB 31078
Quercus alba L., LB 29337
Quercus falcata Michx., LB 30584, 29374, 29977; SJ 13801
Quercus hemisphaerica W. Bartram ex Willd., LB 30282; SJ 14107, 13763
Quercus incana W. Bartram, SJ 14082
Quercus laurifolia Michx., LB 30591, 30174, 29922 SJSEWP 16466
Quercus lyrata Walter, LB 29928; SJ 13783; GW 514
Quercus margaretta (Ashe) Ashe, LB 31173
Quercus marilandica Muench., SJ 13792
Quercus michauxii Nutt., LB 29840; SJ 13850
Quercus nigra L., LB 29385, 29331; SJSEWP 150843
Quercus pagoda Raf., SJ 13844, 13838, 14116
Quercus phellos L., LB 29391, 30025, 29975
Quercus stellata Wangenh., SJ 13793
Quercus velutina Lam., SJ 14056
Quercus virginica Mill., WP 180

GENTIANACEAE

**Centaurium floribundum* (Benth.) B.L. Rob., LB 30583
**Centaurium pulchellum* (Sw.) Druce, LB 30597, 30094; SEEKWP 3075
Sabatia arenicola Greenm., SJ 13870
Sabatia calycina A. Heller, LB 30673
Sabatia campestris Nutt., SJ 14096
Sabatia gentianoides Elliott, MM 3635

GERANIACEAE

Geranium carolinianum L., SEWP 3075; LB 30285

GROSSULARIACEAE

Itea virginica L., SJ 14118, 14023

HALORAGACEAE

Myriophyllum pinnatum (Walter) Britton, Sterns, Poggenb., SJ 13921
Proserpinaca palustris L, SJ 13913; LB 30644
Proserpinaca pectinata Lam., LB 30644; GW 3108; MM 3475; DS 090

HAMAMELIDACEAE

Liquidambar styraciflua L., SJSEWP 15071

HYDROPHYLLACEAE

Hydrolea ovata Nutt. ex Choisy, LB 29958; GW 3109

HYPERICACEAE

Hypericum crux-andreae (L.) Crantz, LB 29412, 29994; SJ 13788; MM 3389
Hypericum galioides Lam., LB 30728, 29944; SJ 14514; MM 4001
Hypericum mutilum L., LB 30002; SJ 14160
Triadenum walteri (J.G. Gmel.) Gleason, LB 30180, 29892, 30780; GW 3093

IRIDACEAE

Sisyrinchium angustifolium Mill., GW 3054; LB 29358; PHCLLB s.n. (SBSC)
Sisyrinchium atlanticum E.P. Bicknell, SJ 13760, 14255; MM 3875; LB 31169
Sisyrinchium langloisii Greene, LB 31174
Sisyrinchium rosulatum E. P. Bicknell, GW 3061; SEWP 3061
Sisyrinchium sagittiferum E. P. Bicknell, GW 3082 LB 30410, 31029

JUGLANDACEAE

Carya aquatica (Michx.) Nutt., LB 29937, 30085
Carya illinoensis K. Koch, LB 30893
Carya texana Buckley, LB 30046; SJ 13970
Carya tomentosa (Lam. ex Poir.) Nutt., LB 30611, 30579
Juglans nigra L., LB 29913

JUNCACEAE

Juncus acuminatus Michx., SJ 13898, 14012
Juncus brachycarpus Weigel, LB 29408; SJ 13899, 14099
Juncus coriaceus Mack., LB 29932, 29945; SJSEWP 15068
Juncus dichotomus Elliott, LB 31167
Juncus diffusissimus Buckley, SJ 13900, 14008
Juncus effusus L., LB 30155; SEWP 3071
Juncus elliottii Chapm., SJ 14061; LB 29342, 31180C
Juncus marginatus Rostk., SJ 14002, 14065; LB 29347
Juncus nodatus Coville, SJ 13901
Juncus repens Michx., SJ 14013 LB 30641
Juncus tenuis Willd., LB 30086; SJ 14074a, 13897
Juncus validus Coville, LB 29334

LAMIACEAE

Hedeoma hispidum Pursh, LB 31166
Hyptis alata (Raf.) Shinners, LB 29885; MM 3484
Lycopus rubellus Moench, LB 30242; PH 901159
Monarda punctata L., LB 29859
**Perilla frutescens* (L.) Britton, LB 29890; GW 3052
Prunella vulgaris L., SJ 13919
Pycnanthemum albescens Torr. & A. Gray, LB 30196, 29954
Salvia coccinea Buchoz ex Etlinger, SJ 14259
Salvia lyrata L., LB 30054; SJSEWP 15047
Scutellaria integrifolia L., SJ 13789, 14549, 14052; MM 3876
Stachys crenata Raf.., LB 30396; SEWP 3068

LAURACEAE

Persea palustris (Raf.) Sarg., LB 30211, 29866, 29381, 29359
Sassafras albidum (Nutt.) Nees, LB 30222

LEMNACEAE

**Landolta punctata* (G. Meyer) Les & D.J. Crawford, LB 29893, 31069
Wolffia brasiliensis Wedd., LB 30878, 31070
Wolffia columbiana H. Karst., LB 31070a
Wolffiella gladiata (Hegelm.) Hegelm., LB 31068

LENTIBULARIACEAE

Pinguicula pumila Michx., SJ 13702; MM 3761

LILIACEAE

Aletris aurea Walter, LB 30028, 29991; SJ 14094; MM 3639
Allium canadense L. var. *canadense*, SJ 13765, 13874
Hymenocallis liriosme (Raf.) Shinners, SEWP 3072
Hypoxis rigida Chapm. LB 30233, 31171
Hypoxis wrightii (Baker) Brackett, LB 31159
**Narcissus tazetta* L., WP 098
Nothoscordum bivalve (L.) Britton, SJSEWP 15046
**Ophiopogon jaburan* Lodd., LB 30092
Schoenolirion croceum (Michx.) Wood, SJ 14548; MM 3783, LB 31057
**Zephyranthes candida* Herb., LB 29911; SE 4581

LINACEAE

Linum medium (Planch.) Britton var. *texanum* (Planch.) Fernald, LB 303728a, 30657; SJ 14055; MM 3546
Linum striatum Walter, LB 30653, 30639; SJ 14169; GW 3075

LOGANIACEAE

Gelsemium sempervirens (L.) Aiton f., LB 29386, 30279; SJSEWP 15038
Mitreola petiolata (J.F. Gmel.) Torr. & A. Gray, LB 29881; SJ 14159
Mitreola sessilifolia (J.F. Gmel.) G. Don, LB 30012; MM 3483; PH 901141

LYCOPODIACEAE

Lycopodiella appressa (Chapm.) Cranfill, GW 3435; WRC 17358, 17228; MM 3734

LYGODIACEAE

**Lygodium japonicum* (Thunb. ex Murray) Sw., LB 29888, 29856; SJSEWP 15045

LYTHRACEAE

**Cuphea carthagenensis* (Jacq.) J.F. Macbr., GW 3076
**Lagerstroemia indica* L., LB 30600
Lythrum alatum Pursh var. *lanceolatum* (Elliott) Torr. & A. Gray, LB 30042; SJ 14270
Rotala ramosior (L.) Koehne, LB 30161; GW 3090

MAGNOLIACEAE

Magnolia grandiflora L., LB 29857; SJ 14239
Magnolia virginiana L., SJ 14038

MALVACEAE

**Abutilon theophrasti* Medik., GW 3134
Hibiscus moscheutos L., LB 30173; GW 3094
Malvastrum coromandelianum (L.) Garcke, GW 3088
Modiola caroliniana (L.) G. Don, SEWP 3064
Sida rhombifolia L., LB 30694
Sida spinosa L., GW 3163

MELASTOMATACEAE

Rhexia lutea Walter, LB 30663; MM 3388; WRC 17227; SJ 14054
Rhexia mariana L., MM 3489; SJ 14155, 14015; GW 3126

MORACEAE

Morus rubra L., LB 29939

MYRICACEAE

Morella caroliniensis (Mill.) Small, SJ 14117, 14062
Morella cerifera (L.) Small, LB 30047; WRC 17356

OLEACEAE

Chionanthus virginicus L., WP 087; LB 29335, 31071
Fraxinus americana L., LB 30251
Fraxinus caroliniana Mill., SJ 14175
Fraxinus pennsylvanica Marshall., LB 29924
**Ligustrum sinense* Lour., LB 29865; SJ 14068

ONAGRACEAE

Gaura lindheimeri Engelm. & A. Gray, LB 30007; WRC 17701; SJ 14510; DS 124
Gaura longiflora Spach, LB 30146
Ludwigia alternifolia L., LB 29879; SJ 14509
Ludwigia decurrens Walter, LB 30152

Ludwigia glandulosa Walter, LB 29987; SJ 14234; GW 3104
Ludwigia grandiflora (Michx.) Greuder & Burdet, GW 3180
Ludwigia hirtella Raf.; LB 29951, 29367; SJ 14171; DS 123
Ludwigia linearis Walter, MM 3538; LB 29959, 29992
Ludwigia microcarpa Michx., LB 30684
Ludwigia octovalvis (Jacq.) P.H. Raven, LB 30725
Ludwigia palustris (L.) Elliott, LB 30669, 30159
Ludwigia peploides (Kunth) P.H. Raven, LB 30148
Ludwigia pilosa Walter, LB 30774, 30122a, 30032; CL 901157
Oenothera biennis L., LB 30247
Oenothera laciniata Hill, SEWP 3069, SJSEWP 15086
Oenothera speciosa Nutt., LB 30624; SEEKWP 3101

OPHIOGLOSSACEAE

Botrychium biternatum (Sav.) Underwood, GW 3051
Ophioglossum crotalophoroides Walter, LB 31050
Ophioglossum petiolatum Hook., LB 30394

ORCHIDACEAE

Calopogon tuberosus (L.) Britton, Sterns, Poggenb., LB 29406, 29392; SJ 14079; MM 3924
Listera australis Lindl., SJ 13698
Spiranthes cernua (L.) L. C. Rich., WP 060
Spiranthes floridana (Wherry) Cory, LB 20418(SBSC)
+*Spiranthes longilabris* MM 4041
Spiranthes odorata (Nutt.) Lindl., LB 30894
Spiranthes praecox (Walter) S. Watson, MM 3863; LB 31178
Spiranthes tuberosa Raf., SJ 14093
Spiranthes vernalis Engelm. & A. Gray, MM 3919

OSMUNDACEAE

Osmunda regalis L. var *spectabilis* (Willd.) A. Gray, LB 29360; WP 098

OXALIDACEAE

Oxalis corniculata L. var. *wrightii* (A. Gray) B.L. Turner, LB 30385; GW 3077
**Oxalis debilis* Kunth var. *corymbosa* (DC.) Lourteig, LB 30389, 30250; SEWP 3051
Oxalis lyonii Pursh, (T) SJSEWP 15055

PASSIFLORACEAE

Passiflora incarnata L., LB 29907; SJSEWP 16461
Passiflora lutea L., LB 30613, 30067

PHYTOLACCACEAE

Phytolacca americana L., SJ 14272 PINf
Pinus echinata Mill., LB 30113a
Pinus palustris Mill., LB 29384
Pinus taeda L., LB 30144, 29399; SEEKWP 3092

PLANTAGINACEAE

**Plantago major* L., LB 30289, 30284
Plantago virginica L., LB 30404, 29882,; SEWP 3060

PLATANACEAE

Platanus occidentalis L., LB 29852

POACEAE

Agrostis hyemalis (Walter) Britton, Sterns, Poggenb., SEWP 3059; SJ 13868
Andropogon glomeratus (Walter) Britton, Sterns, Poggenb., LB 30188; WP 063
Andropogon virginicus L., LB 30882, 30172; CL 901126
Anthaenantia texana Kral, LB 30234; WRC 10840; MM 3727, 3665
Aristida longispica Poir. var. *geniculata* (Raf.) Fernald, LB 30256
Aristida longispica Poir. var. *longispica*, LB 30236a
Aristida palustris (Chapm.) Vasey, LB 30730, 30729; WRC 17232; MM 3542
Aristida purpurascens Poir. var. *virgata* (Trin.) Allred, LB 30237, 30228, 30227, 29956
Arundinaria gigantea (Walter) Muhl., SJSEWP 15072
Axonopus fissifolius (Raddi) Kuhlm., SJ 14113; MM 3653b; LB 30680, 30674
Axonopus furcatus (Flüggé) A. S. Hitchc., LB 29349 PH 901161; SJ 14115
**Briza minor* L., SJSEWP 15053
**Bromus catharticus* Vahl, LB 30599; SEEKWP 3095
Chasmanthium latifolium (Michx.) Yates, SJ 14252
Chasmanthium laxum (L.) Yates var. *laxum*, LB 29839
Chasmanthium laxum (L.) Yates var. *sessiliflorum* (Poir.) Wipff & S. Jones, LB 30717
Coelorachis rugosa (Nutt.) Nash, LB 30736; MM 3721, 3637
**Cynodon dactylon* (L.) Pers., LB 30621; SEEKWP 3086
Dichanthelium aciculare (Desv. ex Poir.) Gould & Clark var. *angustifolium* (Elliott) S.L. Hatch, LB 30588, 31184, 30035; SJ 14459
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *acuminatum* SJ 14556; LB 29357, 30695
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *densiflorum* (E.L. Rand & Redfield) Gould & C.A. Clark, LB 29371
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *longiligulatum* (Nash) Gould & C.A. Clark, LB 30626, 29346; MM 3482; CL 901136
Dichanthelium boscii (Poir.) Gould & Clark, LB 30609, 29908, 30876, 31230
Dichanthelium commutatum (Schultes) Gould subsp. *commutatum*, LB 29883, 29982; SJSEWP 15058
Dichanthelium commutatum (Schultes) Gould subsp. *equilaterale* (Scribner) Freckman & Lelong, LB 30063 (SBSC)
Dichanthelium consanguineum (Kunth) Gould & C.A. Clark LB 30650; MM 3862
Dichanthelium dichotomum (L.) Gould var. *dichotomum*, LB 30586, 30585, 30642a, 29897
Dichanthelium dichotomum (L.) Gould & C.A. Clark subsp. *microcarpon* (Muhl. ex Elliott.) Freckman & Lelong, LB 30642, 29897, 29986
Dichanthelium dichotomum (L.) Gould subsp. *nitidus* (Lam.) Freckman & Lelong,, LB 31162

Dichanthelium ensifolium (Baldw. ex Elliott) Gould subsp. *ensifolium*, LB 30089, 29897
Dichanthelium laxiflorum (Lam.) Gould, LB 29842; SJSEWP 15057
+*Dichanthelium ovale* (Elliott) Gould & C.A. Clark WRC 17362
Dichanthelium ovale (Elliott) Gould & C.A. Clark subsp. *villosissimum* (Nash) Freckman & Lelong, LB 30660, 30651; SJ 14554; WRC 17366
Dichanthelium polyanthes (Schult.) Mohlenbr., LB 30589, 31319
Dichanthelium ravenelii (Scribner & Merr.) Gould & C.A. Clark, LB 30699
Dichanthelium scabriusculum (Elliott) Gould & C.A. Clark, LB 30034, 29980, 29348
Dichanthelium scoparium (Lam.) Gould, LB 30659, 30261, 29370; SJ 14042
Dichanthelium sphaerocarpon (Elliott) Gould, LB 29345, 30004; SJ 14460
Dichanthelium tenue (Muhl.) Freckman & Lelong, LB 29377; SJ 14557
Dichanthelium wrightianum (Scribn.) Freckmann, MM 3385
Digitaria ciliaris (Retz.) Koel., LB 30226, 30190, 29903, 30072
**Digitaria ischaemum* (Schreb.) Schreb. LB 30189
Echinochloa walteri (Pursh) Heller, SJ 14290
**Eleusine indica* (L.) Gaertn., LB 30078
Elymus virginicus L., SJ 14276
Eragrostis elliottii S. Watson, LB 30187; PH 901148
Eragrostis hypnoides (Lam.) Britton, Sterns, Poggenb., LB 30177
Eragrostis refracta (Muhl.) Scribn., GW 2400; MM 3654
Eragrostis secundiflora (J. Presl) subsp. *Oxylepis* (Torr.) S. D.Koch, LB 29872; SJ 14075; PH 901143
**Eremochloa ophiuroides* (Munro) Hack., LB 30065
Hordeum pusillum Nutt., LB 30405; SEEKWP 3085
Leersia hexandra Sw., LB 30038
Leersia lenticularis Michx., LB 30166a; SJ 14172
Leersia virginica Willd., LB 30197; SJ 13856
**Lolium arundinaceum* (Schreb.) S.J. Darbyshire, SJ 15095
Melica mutica Walter, SJ 13697
Muhlenbergia capillaris (Lam.) Trin., CI 901128; MM 3656; LB 30900, 31081
Muhlenbergia expansa (Poir.) Trin., GW 2408a; MM 3724 (SBSC)
Oplismenus hirtellus (L.) Beauv., LB 30169, 29916
Panicum anceps Michx., LB 29899; PH 901140
Panicum brachyanthum Steud., LB 30187; CL 901156
Panicum dichotomiflorum Michx., LB 30711, 30888
Panicum gymnocarpon Elliott, LB 30779
Panicum hemitomon J.A. Schultes, SJ 14019
**Panicum repens* L., LB 29343
Panicum rigidulum Bosc ex Nees, LB 30175; PH 901163, 901167, MM 3732
Panicum tenerum Bey. ex Trin., LB 19343, 30019; WRC 17698; MM 3487
Panicum verrucosum Muhl., MM 3666; LB 30184, 30259
Panicum virgatum L., LB 30111
**Parapholis incurva* (L.) C.E. Hubbard, SJ 13865
**Paspalum dilatatum* Poir., LB 29884
Paspalum floridanum Michx., LB 30192, 30123, 30770
Paspalum laeve Michx., LB 30775, 30171, 29963; MM 3663
Paspalum langei (Fourn.) Nash, LB 29902a; SJSEWP 16460
Paspalum lividum Trin., LB 30162
Paspalum minus Fourn., LB 30879, 30640, 30096, 19238 (SBSC)
**Paspalum notatum* Flüggé, LB 29964, 29405, 19238 (SBSC)
Paspalum plicatulum Michx., SJ 14067
Paspalum praecox Walter, LB 30026; CL 901158; SJ 14105; MM 3731
Paspalum setaceum Michx., LB 29876, 29870a
**Paspalum urvillei* Steud., LB 29942; GW 3023; SEEKWP 3093
**Poa annua* L., SJSEWP 15061
Poa autumnalis Muhl. ex Elliott, LB 31055
**Polypogon monspeliensis* Muhl. ex Elliott, LB 30606
Saccharum baldwinii Sprengel., LB 30168, 29931, 30773
Saccharum giganteum (Walter) Pers., LB 30147, 30892
Schizachyrium scoparium (Michx.) Nash var. *divergens* (Hack.) Gould, PH 901145; CL 901122; DW s.n.
Sorghum halepense (L.) Pers., LB 30594, 29941; SEEK 3084
Sphenopholis obtusata (Michx.) Scribn., SJ 13915; GW 2246b; LB 31164
Sporobolus indicus (L.) R. Br., LB 30622, 29909
Sporobolus silveanus Swallen, LB14907 (SBSC), 14702 (SBSC); PH 901147
Steinchisma hians (Elliott) Nash, SJ 13892
Tridens ambiguus (Elliott) J.A. Schultes, WRC 17234; CL 901120; GW 2406; MM 3544
Tridens flavus (L.) Hitchc. var. *flavus*, LB 29923; WP 066
Tridens strictus (Nutt.) Nash, LB 30145, 30258; CL 901121; MM 3722
Tripsacum dactyloides (L.) L., SJ 14025
Urochloa platyphylla (Munro ex Wright) R. Webster, GW 3164

POLYGALACEAE

Polygala cruciata var. *cruciata* L., LB 29995; SJ 14111, 14425, 14293
Polygala incarnata L., LB 30655
Polygala leptocaulis Torr. & A. Gray, LB 30691, 30687; SJ 14161, 13993
Polygala mariana Mill., LB 29400, 30027; MM 3726
Polygala ramosa Elliott, LB 30017; SJ 14158; MM 3877

POLYGONACEAE

Brunnichia ovata (Walter) Shinners, LB 29846

**Polygonum cespitosum* Blume var. *longisetum* (De Bruyn) Stewart, LB 31318
Polygonum densiflorum Meisn., LB 30179; GW 3166a
Polygonum hydropiperoides Michx., SJ 13891
Polygonum punctatum Elliott, WP 064; LB 30150, 30084a; GW NO2
Polygonum virginianum L., LB 30088, 30209
**Rumex crispus* L., SJ 13859, 14251
Rumex chrysocarpus Moris, LB 31234
**Rumex pulcher* L., LB 30605; SEEKWP 3089

POLYPODIACEAE

Pleopeltis polypodioides Andrews & Windham subsp.*michauxiana* (Weatherby) Andrews & Windham, LB 30084

PRIMULACEAE

**Anagallis arvensis* L., SJSEWP 15051
Anagallis minima (L.) E.H.L. Krause, LB 31178a
Samolus valerandi L. subsp. *parviflorus* (Raf.) Hultén, LB 29889; SJ 13831

RANUNCULACEAE

Clematis crispa L., LB 30723, 30580; WP 092; SJ 14262
Ranunculus hispidus Michx. var. *nitidus* (Chapm.) T. Duncan, SJSEWP 15064
Ranunculus pusillus Poir., SJSEWP 15074

RHAMNACEAE

Berchemia scandens (Hill) K. Koch, LB 29874; SEWP 3049
Rhamnus caroliniana Walter, WP 099

ROSACEAE

Crataegus berberifolia Torr. & A. Gray, SJ 14249
Crataegus brachyacantha Sarg. & Engelm., LB 30205, 29930; GW 3041
Crataegus marshallii Eggiest., SJ 14244
Crataegus opaca Hook. & Arn., SJ 13761; LB 30206, 29836, 19244
Crataegus spathulata Michx., LB 30679
Crataegus viridis L., SJ 14253
**Duchesnea indica* (Andr.) Focke, SJSEWP 15062
Photinia pyrifolia (Lam.) K.R. Robertson & J.B. Phipps, LB 29402; SJSEWP 15039; SJ 13996
Prunus caroliniana (Mill.) Aiton, SJ 13909
Prunus serotina Ehrh., SJ 14108
**Pyracantha koidzumi* (Hayata) Rehder, SEWP 3055
**Rosa bracteata* J.C. Wendl., SJ 14063
Rubus argutus Link, LB 30873, 30577; SEEKWP 3082
Rubus trivialis Michx., SJSEWP 15052
**Spiraea cantoniensis* Lour., LB 30398a

RUBIACEAE

Cephalanthus occidentalis L., SJ 14258; LB 30384
Diodia teres Walter, LB 29873
Diodia virginiana L., LB 29990a; MM 3475
Galium aparine L., SJSEWP 15094
Galium obtusum Bigelow, SJ 14268a
Galium pilosum Aiton, LB 30593; SJ 14241; SJSEWP 16462; GW 3066
Galium tinctorium (L.) Scop., SJSEWP 15073
Gardenia augusta Merr., SJ 14143
Houstonia pusilla Schoepf, LB 30393; SJSEWP 15060
Mitchella repens L., LB 29841, 30074; SJ 13794
Oldenlandia boscii (DC.) Chapm., LB 30662, 30220
Oldenlandia uniflora L., GW 3420
**Sherardia arvensis* L., SEWP 3070; SJSEWP 15082
Stenaria nigricans (Lam.) Terrell, SJ 14039; PH 901162; LB 31226

RUTACEAE

**Poncirus trifoliata* (L.) Raf., SJ 14254

SALICACEAE

Salix nigra Marshall., LB 29949

SARRACENIACEAE

+Sarracenia alata Wood, LB 30726; SJ 13777; WRC 17354

SAURURACEAE

Saururus cernuus L., LB 29835; SJ 14168

SCROPHULARIACEAE

Agalinis fasciculata (Elliott) Raf., SJ 13861, 14506
Agalinis heterophylla (Nutt.) Small ex Britton, LB 30208; GW 3135, 3401
Agalinis purpurea (L.) Pennell, LB 30875, 30214, 30144a; GW 3129
Agalinis viridis (Small) Pennell, LB 30218
Aureolaria flava (L.) Farw. var. *flava* LB 29955, 30001; SJ 14045, 14236
Bacopa caroliniana (Walter) Robins. LB 30778
Bacopa monnieri (L.) Pennell, LB 30203, 29886
Gratiola brevifolia Raf., LB 29364; SJ 14003; GW 3117; MM 3916
Gratiola pilosa Michx., LB 30000; GW 3127; PH 901155
Gratiola virginiana L., SJSEWP 15075
**Lindernia crustacea,* (L.) F. Muell., LB 29900, 30080
Mecardonia acuminata (Walter) Small, LB 30200, 30100; PH 901142
Mecardonia procumbens (Mill.) Small, SJSEWP 15089; GW 3160
Micranthemum umbrosum (J.G. Gmel.) Blake, LB 30178, 30164
Scoparia dulcis L., LB 30719, 30204, 29901; SJ 14072
**Verbascum thapsus* L., GW 3047
**Veronica arvensis* L., LB 30401
Veronica peregrina L., LB 30401a, 30386
**Veronica polita* Fries, LB 30290

SELAGINELLACEAE

Selaginella apoda (L.) Spring, SJSEWP 15077; LB 30281

SMILACACEAE

Smilax bona-nox L., SEWP 3050, SJ 14066
Smilax glauca Walter, LB 30182, 30022; SJ 14007
Smilax laurifolia L., SJ 13778; LB 29389, 30113, 30874
Smilax pumila Walter, LB 30225, 29894; SJ 13904
Smilax rotundifolia L., LB 29365

Smilax smallii Morong, LB 30040
Smilax walteri Pursh, GW 2405

SOLANACEAE
Physalis cordata Mill., GW 3153
Physalis pubescens L., LB 30399; GW 3065
Solanum carolinense L., SEEKWP 3076; LB 29875
Solanum elaeagnifolium Cav., SJ 14246; GW 3146

STYRACACEAE
Styrax americanus Lam. LB 30384a, 30243; SJ 13910
Styrax grandifolius Aiton, SJ 14005

SYMPLOCACEAE
Symplocos tinctoria (L.) L'Her, LB 29834, 29378, 30095; WRC 17360

THELYPTERIDACEAE
Thelypteris kunthii (Desv.) Morton, LB 29898; SJ 13933

TYPHACEAE
Typha latifolia L., LB 31073

ULMACEAE
Celtis laevigata Willd., LB 29861
Planera aquatica J.F. Gmel., LB 30156, 29932; SJSEWP 15061
Ulmus alata Michx., LB 29920; SJSEWP 15067
Ulmus americana L., LB 29858, 30288

URTICACEAE
Boehmeria cylindrica (L.) Sw., LB 30616, 29891, 30052

VALERIANACEAE
Valerianella radiata (L.) Dufr., SJSEWP 15088

VERBENACEAE
Callicarpa americana L., WP 179
**Glandularia pulchella* (Sweet) Troncoso, SJ 14247; SJSEWP 15087
Lantana urticioides Heyek, GW 3141
Phyla nodiflora (L.) Greene, SEEKWP 3079; LB 29869; SJ 14097
**Verbena brasiliensis* Vell., LB 30722; SEEKWP 3080
Verbena halei Small, LB 30070; SEEKWP 3114
Verbena scabra Vahl, LB 29902

VIOLACEAE
Viola lanceolata subsp. *vittata* (Greene) Russell., WRC 17357; SJ 13699; MM 3762; LB 30296
Viola palmata L., SJSEWP 15059; SJ 13700; GW 30469; LB 30294
Viola sororia Willd. var *missouriensis* (Greene) McKinney, GW 3050; LB 31067

VISACEAE
Phoradendron serotinum (Raf.) M.C. Johnston, SJ 14505; GW 3173

VITACEAE
Ampelopsis arborea (L.) Koehne, WP 067; LB 29934
Parthenocissus quinquefolia (L.) Planch., LB 29850
Vitis aestivalis Michx., LB 30724, 30062; SJ 14105
Vitis cinerea (Engelm) Millard. var. *cinerea*, LB 29326; SJ 14116a
Vitis rotundifolia Michx., SEEKWP 3087; LB 30219, 30003a

XYRIDACEAE
Xyris ambigua Bey. ex Kunth, LB 29419, 30116; SJ 14083; GW 3446
Xyris baldwiniana Schult., LB 29413; SJ 14045a
Xyris difformis Chapm. var. *difformis*, MM 3657
Xyris jupicai L. C. Rich., LB 30218a; SJ 14275
Xyris laxifolia Mart. var. *iridifolia* (Chapm.) Kral, LB 30083; GW 3107a
Xyris stricta Chapm. var. *obscura* Kral, LB 30109, 29950, 29981; MM 3535

Notes

Coreopsis gladata.—We are merging *C. linifolia* with this species following Strother (2006).

Dichanthelium ovale.—*WRC 17362* has the papilose-based hairs of subsp. *villosissimum* but the longer (up to 3 mm) spikelets of subsp *ovale* (refer to Diggs et al. 2006). Thus we are unable to assign a subspecies to this collection.

Echinacea pallida var. **sanguinea.**—This globally rare (G3) species was once on the Texas rare plant list (Pool et al. 2002; Wildlife Diversity Program 2004). It occurs in many east Texas counties (Turner et al. 2003).

Eupatorium semiserratum.—Although not mapped in Texas by Turner et al. (2003) nor by Siripum and Schilling (2006), plants matching the key characters and description in Siripum and Schilling (2006)are found in east Texas.

Lechea minor.—This is the first report of this species for Texas.; details are to be provided in a future publication.

Pluchea baccharis.—An older name for *P. rosea*.

Sarracenia alata.—This species was introduced to the Lance Rosier Unit in the 1960s or

1970s where it has thrived. It occurs naturally and is common in other parts of the Big Thicket region.

Soliva anthemifolia.—This name replaces *S. mutisii* in Flora of North America volume 19.

Spiranthes longilabris.—This globally rare (G3) species was once on the Texas rare plant list (Pool et al. 2002; Wildlife Diversity Program 2004). In Texas, it occurs in wetland pine savannas only in Hardin and Newton Counties (Liggio & Liggio 1999).

Vicia hirsuta.—Jerry Flook (1975) reported this introduced legume from Shelby County and Turner et al. (2003) mapped it only in this county. It is a frequent weed near the site of the former Teel residence along the road to Little Pine Island Bayou.

DISCUSSION

There are 114 families (113 native) and 352 genera (311 native) for the 694 taxa (612 native) on the Lance Rosier Unit list. Ten percent of the taxa are non-native. Eight families: Poaceae (96 taxa), Cyperaceae (87 taxa), Asteraceae (84 taxa), Fabaceae (38 taxa), Scrophulariaceae (19 taxa), Onagraceae (16 taxa), Rosaceae (15 taxa), Euphorbiaceae (15 taxa), and Rubiaceae (14 taxa), account for 56 % of the taxa collected. The largest genera are *Carex* (31 taxa), *Dichanthelium* (21 taxa), *Rhynchospora* (19 taxa), *Cyperus* (15 taxa), *Quercus* (15 taxa), and *Juncus* (12 taxa).

We compared the present list of species for Lance Rosier Unit with a sample of the species reported by Turner et al. (2003) in their *Atlas of the Vascular Plants of Texas* and found that only 74% of the species on the Lance Rosier Unit list are reported as occurring in Hardin County in that source. This is not surprising considering that, until recently, little focused collecting has been undertaken in the Big Thicket region. Basic floristic collecting and documenting in the Big Thicket region are still needed.

While it is the case that our list is incomplete, as are all floras, and a few taxa reported here may no longer exist on the unit. Most taxa that have grown in the Lance Rosier Unit during the past quarter century have been collected (probably 85+ %). We estimate that the Lance Rosier Unit has about 620 to 705 native species/taxa.

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Book Review

Kendall R. Lamkey and Michael Lee (Eds.). 2006. **Plant Breeding: The Arnel R. Hallauer International Symposium.** (ISBN 0-8138-2824-4, 978-0-8138-2824-4, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** 515-292-0140, 515-292-3348 fax 1-800-862-6657, www.blackwellprofessional.com, orders@ames.blackwellpublishing.com,). $149.99, 379 pp., numerous illustrations, 7" × 10".

A total of 84 authors contribute a collection of 27 chapters, the first "Plant Breeding: Past, Present, and Future." From the Preface: "The world of plant breeding has experienced dramatic changes during the [last 45 years]. At the institutional level, international centers of crop development have emerged and declined, legal and ethical issues have become routine considerations, the private sector (national programs, federal governments, universities) has diversified and placed greater emphasis on basic research as opposed to varietal development. Changes in infrastructure (e.g., off-season nurseries, service laboratories) and technology (e.g., computers, machinery, analytical methods, transgenic methods) enable the declining number of plant breeders to evaluate more germplasm in more ways in more environments and to identify genotypes that exhibit optimal adaptation to the needs of society, the demands of nature, and the desires of the market. Nascent developments in basic biological and informational sciences, as exemplified by the gradual annotation of entire genomes and their gene products, have provided additional tools and options for various aspects of plant breeding."—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

Book Notice

M. Nevin Smith. 2006. **Native Treasures: Gardening with the Plants of California.** (ISBN 0-520-24425-7, pbk.). University of California Press, California/Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A. (**Orders:** www.ucpress.edu/, 609-883-1759, 609-883-7413 fax). $24.95, 278 pp., color photos, 7" × 10".

From the author:—"This is not a 'how-to' gardening book, though practical subjects are addressed here in detail, and it is certainly not the comprehensive encyclopedia ... Rather, it combines my own personal thoughts, sometimes maverick opinions, and experience with a goodly measure of plainer facts on selected groups of native plants and their culture. The plant genera described here include most of the major ones in cultivation, but also some more obscure but garden-worthy groups, thrown in as whim and personal interests dictate." Smith divides his favorites into "trees" (oaks, madroño), "shrubs" (e.g., wild lilac, manzanitas, flannel bushes, giant poppies), "two broader genera" (sage and buckwheat), "subshrubs and herbaceous perennials" (e.g., penstemons, iris, lewisias, blue eyes, golden eyes), and "bulbs and corms" (lilies, brodiaeas and friends). He ends with "Small Matters—The trouble with annuals": "We forget that Nature's best displays are occasional and unpredictable. We tell ourselves that anything seen over such vast areas [floors of annual wildflowers] *must* be easy to grow. And so they are, in a well tended flower pot. Creating a reliable display in the open garden is more difficult—as I have learned through harsh experience."

The book is implicitly, at least, aimed toward California gardeners, but surely many of the species could be grown elsewhere in North America. "California gardeners, like their counterparts the world over, can be woefully ignorant of the flora close at hand. They are influenced by a long and hallowed tradition of importing horticultural treasures from Europe, Asia, and other far-flung regions." But .... "A fair number of native plants are now used interchangeably with exotics of similar features even by gardeners whose notion of geographic origin in the local nursery." Even for non-gardeners, this is a great book with lots of interesting biology, fun to read, even if you're not from California.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

AN UPDATED, ANNOTATED VASCULAR FLORA OF CADDO PARISH, LOUISIANA, WITH NOTES ON REGIONAL PHYTOGEOGRAPHY AND ECOLOGY

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ABSTRACT

It has been a quarter century since a checklist of the vascular flora of Caddo Parish, Louisiana, was published. Therefore, we revise and update the Caddo Parish checklist, accepting only vouchered species. We found 1405 species (1168 native, 237 non-native). Additionally, we examine the Caddo Parish flora in terms of its phytogeographical affinities. It is closely associated with the eastern United States and particularly with the southeastern United States. Caddo Parish appears to be particularly species rich compared to other parishes and counties of approximately the same size across the southeast. This may be not only because Caddo Parish is diverse but because it has been particularly well-collected. Among communities occurring in Caddo Parish, xeric sandylands are particularly well-represented and account for a high percentage of West Gulf Coastal Plain endemic and rare species.

KEY WORDS: Floristic checklist, Caddo Parish, Louisiana flora

RESUMEN

Hace ya un cuarto de siglo que se publicó el catálogo de la flora vascular de Caddo Parish, Louisiana. Por ello, revisamos y ponemos al día el catálogo de Caddo Parish, aceptando únicamente especies con pliegos testigo. Encontramos 1405 especies (1168 nativas, 237 no nativas). Además, examinamos la flora de Caddo Parish en términos de sus afinidades fitogeográficas. Está muy asociada con el este y particularmente con el sureste de los Estados Unidos. Caddo Parish parece ser particularmente rico en especies comparado con otros condados de aproximadamente el mismo tamaño en el sureste. Esto puede que no sea solo porque Caddo Parish es diverso sino porque ha sido particularmente bien muestreado. Entre las comunidades que aparecen en Caddo Parish, están muy bien representados los campos arenosos xéricos y aparece un alto porcentaje de especies raras y endémicas de la llanura costera del oeste del golfo.

INTRODUCTION

Caddo Parish, Louisiana, is located in the Red River watershed in the center of the West Gulf Coastal Plain (Fig. 1). It is bordered on the north by Arkansas, the west by Texas, the east by the Red River, and the south by DeSoto Parish. The only boundary that could be considered ecologically significant is the Red River; the remainder are political. Approximately equidistant from Caddo Parish are blackland prairies to the west, the Ouachita Mountains to the north, the Mississippi River and its extensive floodplain to the east, and the Gulf of Mexico to the south. Caddo Parish is located in the Oak-Pine-Hickory phytogeographical region of eastern North America (Braun 1950; Skeen et al. 1993; MacRoberts

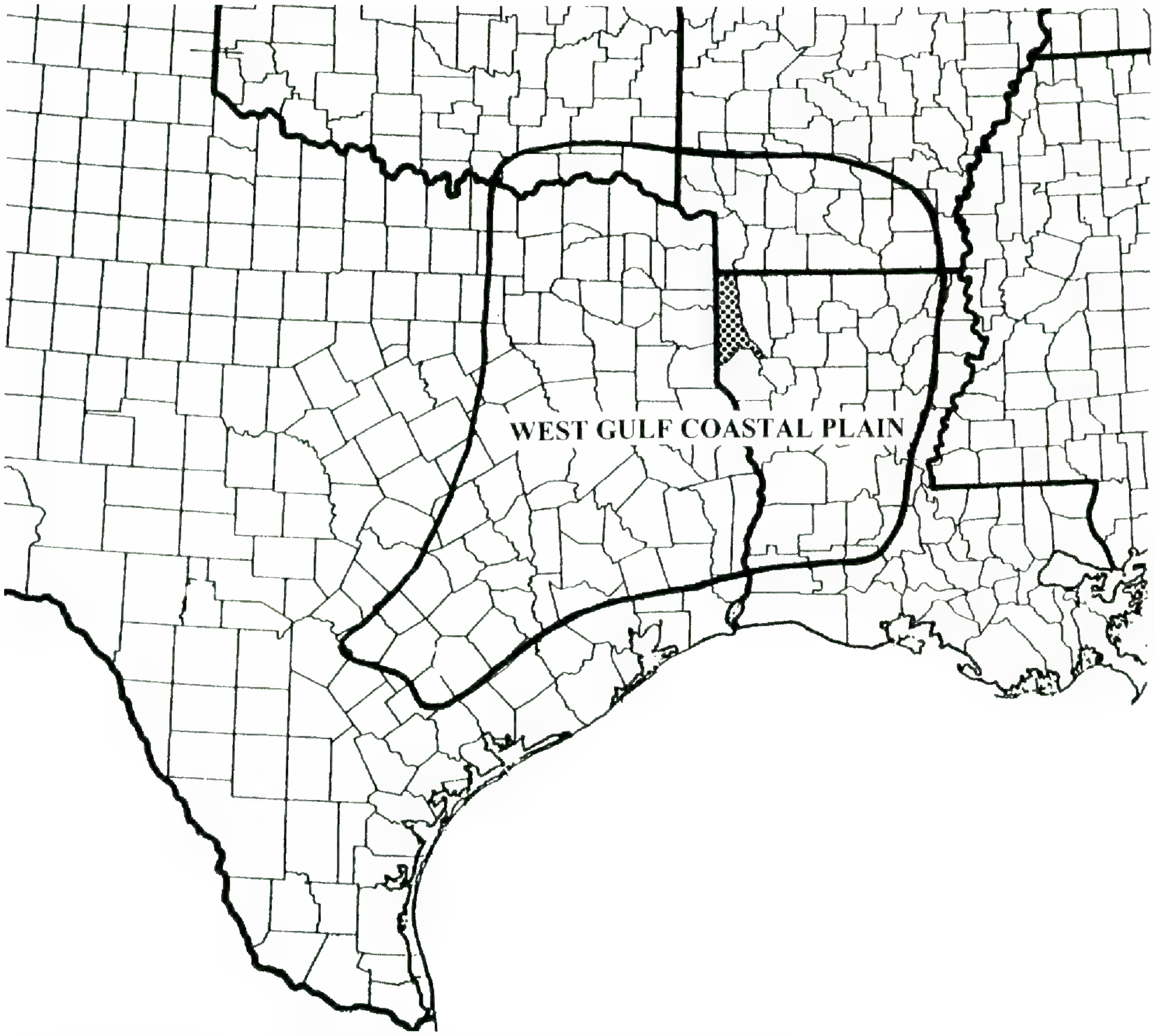


Fig. 1. Location of Caddo Parish, Louisiana.

& MacRoberts 2003a). McLaughlin (in press) places it in the Austroriparan floristic subprovince, with some characteristics of Comanchian and Illinoian subprovinces.

The topography of Caddo Parish is relatively simple. The Red River floodplain covers about 28 percent of the 2,283 km sq. parish; the remainder is uplands (Fig. 2). The floodplain forms a continuous north-to-south border along the eastern edge of the parish. The floodplain can be narrow as when the river approaches a bluff, but it is generally several kilometers wide. At the edge of the river are natural levees and swales. Floodplain elevations range from approximately 60 meters at the northern edge of the parish to about 43 meters at the southern edge. The overall north-south slope is very slight. Sediments are almost entirely of Red River alluvial origin and are Pleistocene/Holocene (Edwards et al. 1980).

Uplands flank the floodplain at its western edge. This often involves an abrupt elevation transition generally in the range of 10 to 20 meters. Elevations rise to no more than 137 meters in rolling low hills and relatively flat terraces. The upland is geologically older than the alluvium and generally consists of Tertiary deposits. The geology, soils, and climate of Caddo Parish are described by Teague and Wendt (1994) and are a continuum of east Texas (Diggs et al. 2006).

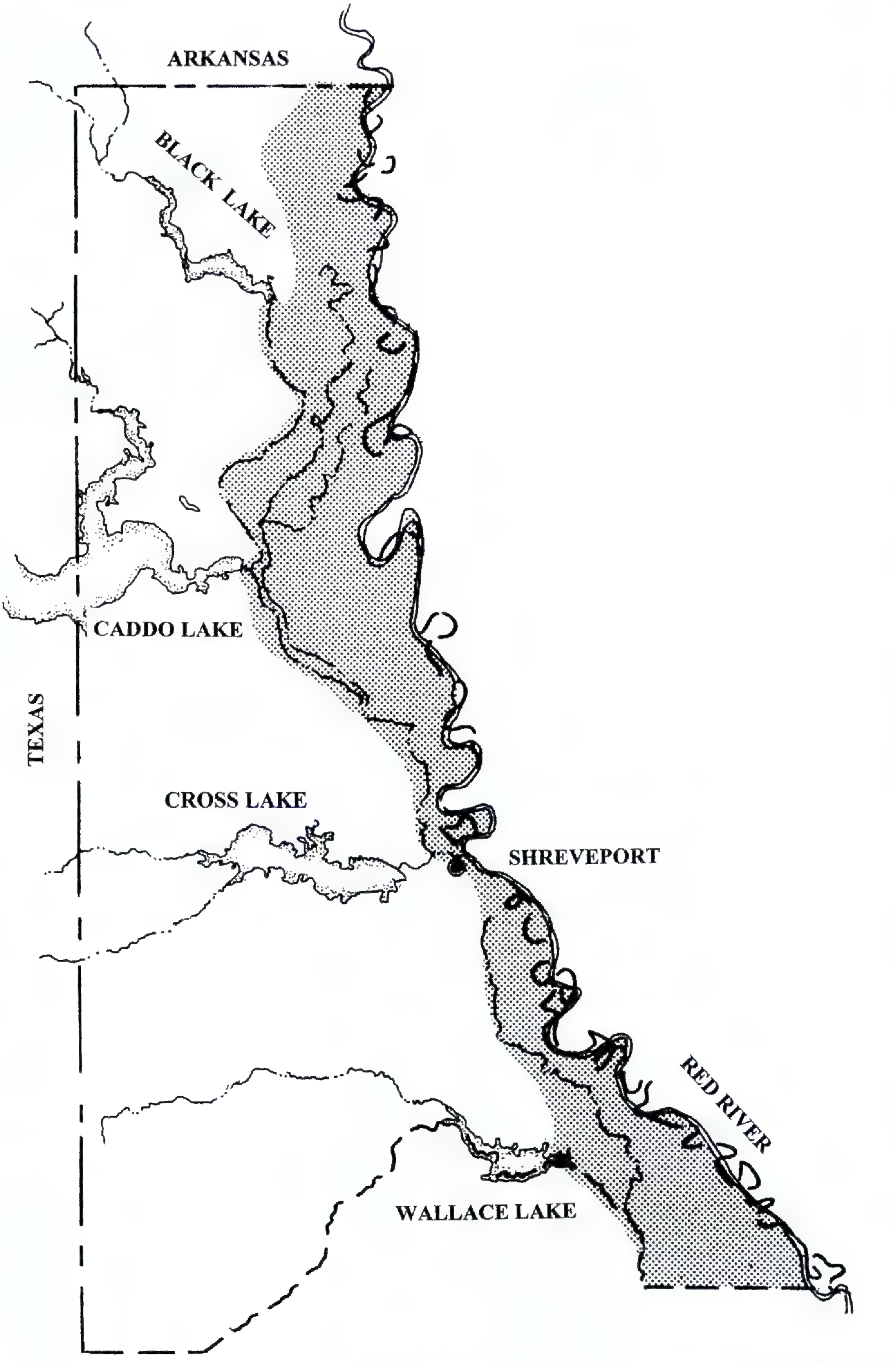


FIG. 2. Caddo Parish showing upland and floodplain (stippled).

Land surveys conducted by the Government Land Office in the 1830s show that in presettlement times the uplands were dominated by oak, pine, and hickory and the floodplains by cottonwood, sycamore, willow, pecan, box elder, ash, cypress, and hackberry, with essentially no overlap in species between upland and floodplain (MacRoberts & MacRoberts 2005). In some parts of the uplands, pine was nearly absent and oak and hickory were dominant; in others, pine reached about 50 percent of the canopy. There appeared to have been no monospecific pine forest in Caddo Parish. The distribution of woody species appears to be the same today as it was 170 years ago (MacRoberts & MacRoberts 2005).

Historically, prairies were scattered across the region in both the uplands and floodplain (MacRoberts et al. 2003; MacRoberts & MacRoberts 2004a). The large "Caddo Prairies" on the floodplain near modern day Gilliam and Hosston no longer exist, and we have little or no information about them aside from the brief descriptions Custis and Freeman made in 1806 and those in the Government Land Office survey maps and line notes (Flores 1984; MacRoberts & MacRoberts 2005). Canebrakes and cedar forests apparently were common in the early nineteenth century but are entirely gone today (Flores 1984; MacRoberts et al. 1997). The Red River Raft, an immense logjam long since cleared, caused extensive flooding and the creation of "raft lakes," the water level of which rose and fell with the annual fluctuations of the river (Triska 1984). Wallace, Cross, and Caddo lakes are impounded remnants of the raft lakes and continue to be dominated by cypress. Oxbow lakes are common on the floodplain.

While the effects of Native Americans on the Caddo Parish landscape are unknown, the effects of Euroamericans have been extensive. The river, its floodplain, and adjacent upland ecosystems have undergone major modification over the past two centuries. Essentially the entire landscape has been converted to farms and plantations and, latterly, urban sprawl. The once continuous savanna/forest with its numerous plant communities covering hundreds of thousands of hectares is now essentially gone with only fragments of the natural vegetation remaining and few areas, if any, in virgin condition. Baldcypress swamps, black willow riverbank shrublands, and cottonwood forests hang on while some floodplain communities such as cedar forests, canebrakes, and prairies have vanished entirely. The upland has also been modified, mainly by urban sprawl, logging, fire suppression, and clearing for farms. Vast areas of forest were clear-cut in the latter part of the nineteenth and early part of the twentieth century and replanted as pine plantations.

Caddo Parish is one of the best collected and reported Louisiana parishes and is certainly the best collected and reported parish or county in the "Ark-La-Tex" region—northeastern Texas, southwestern Arkansas, and northwestern Louisiana (Smith 1988; Thomas & Allen 1993–1998; Turner et al. 2003).

Caddo Parish was first visited and collected by Peter Custis in 1806 (Flores 1984; MacRoberts et al. 1997; MacRoberts & MacRoberts 2004b). Josiah Hale collected in the parish in the mid-nineteenth century. N.F. Peterson from Louisiana State University and Reginald W.S. Cocks from Tulane University collected in Caddo Parish in the early twentieth century. F.W. Pennell from the Academy of Natural Sciences in Philadelphia worked briefly in the area in 1913 when he collected the only known example of *Agalinis caddoensis* (MacRoberts 1978b; Canne-Hilliker & Debrule 1993). E.J. Palmer from Missouri Botanical Garden and D.S. and H.B. Correll (1941), working out of Duke University, collected in the area in the late 1930s. Clair A. Brown from Louisiana State University

sporadically collected in Caddo Parish through the mid-century. John W. Thieret, then at the University of Southwestern Louisiana in Lafayette (now University of Louisiana in Lafayette), collected in Caddo Parish in the 1960s. During the early 1970s, Roselie Overby (1974) collected the flora of Caddo Parish for her thesis at the University of Louisiana at Monroe (formerly Northeast Louisiana University) under the direction of R. Dale Thomas, who also collected regularly in the parish into the twenty-first century. Upon beginning the herbarium at Louisiana State University in Shreveport in the early 1970s, D.T. MacRoberts collected the parish for the next three decades. His collections and those of various students and faculty resulted in numerous contributions to the flora of Louisiana (MacRoberts 1977a, 1977b, 1978a, 1978b, 1979a, 1979b, 1980a, 1980b, 1980c, 1984a, 1984b, 1987, 1989; MacRoberts et al. 1997). Allen et al. (2004) collected mainly grasses in Caddo Parish through the late twentieth and early twenty-first centuries. Special studies have been undertaken such as those of xeric sandylands in northern Caddo Parish (MacRoberts & MacRoberts 1995) and the Bickham-Dickson Park/Red River Watershed Research Park on the Red River floodplain in Shreveport (MacRoberts & MacRoberts in prep.). Other notable collections are those of Larry Raymond from the Walter Jacobs Memorial Park, near Blanchard (Thomas et al. in press). The Louisiana Natural Heritage Program has been active in documenting the rare flora of Caddo Parish (Louisiana Natural Heritage Program 2006; Reid & Faulkner in press).

The purpose of this paper is to provide an updated, vouchered checklist of the vascular flora of Caddo Parish, put Caddo Parish in its phytogeographic context, summarize data on rare plants found in Caddo Parish, and summarize data on regional endemics. The construction of the list has been both aided and hampered by precedents. While previous lists often provided information on where specimens might be found, they did not do so invariably. Although we located vouchers for most reported taxa, many reported taxa could not be located, presumably because the specimens were misfiled (lost), out on loan, initially misidentified and subsequently annotated to another taxon, or were located in an unspecified herbarium. Additionally, some authors reported taxa for which no voucher was collected (i.e., "sight records").

METHODS

Using published accounts (MacRoberts 1979a, 1984a, 1989; Gandhi & Thomas 1989; Thomas & Allen 1993–1998; MacRoberts & MacRoberts 1995; Allen et al. 2004; Louisiana Natural Heritage Program 2004, 2006; Thomas et al. in press; MacRoberts & MacRoberts in prep.), we compiled a checklist (with vouchers where possible) of species reported for Caddo Parish. We then checked the list against Kartesz and Meacham (1999) and *Flora of North America* (Flora of North America Editorial Committee 1993–2006) to eliminate synonyms and to correct nomenclature. We searched LSUS and NLU for vouchers in addition to obtaining loans from BRIT, DUKE, LAF, LSU, LTU, MO, NLU, NO, and US.

Some authors included various waifs and garden and horticultural "escapes" (e.g., corn [*Zea mays* L.], and okra [*Abelmoschus esculentus* (L.) Moench]) and we had to make a judgement as to their status in the flora. We decided to eliminate almost all of these unless we had good reason to believe that they are propagating themselves in the wild or at least persisting.

Our taxonomic viewpoint favors "lumping" and we do not concern ourselves here with taxa below the species level, the reason being that not only are authors inconsistent on the number of infraspecific taxa recognized (e.g., compare Smith 1994; Thomas & Allen

1993–1998; Turner et al. 2003) but also on how to divide (and identify) the often subtle morphological differences between certain species. Consequently, when comparing floristic richness between various geographic areas, our list should be recognized as a "species' list, not a "taxa" list. We do not include species on the vouchered list that we have not inspected except for some *Cyperus* determined by D. Ferguson (LSU, pers. comm.) and two specimens determined by C. Reid (Louisiana Natural Heritage Program, pers. comm.).

Nomenclature and authorities follow Kartesz and Meacham (1999) in most cases. For acaulescent violets, we follow McKinney (1992) and McKinney and Russell (2002). For *Gamochaeta*, we follow Nesom (2004a, 2004b).

In order to put Caddo Parish into a phytogeographic context, we randomly selected 417 native species from our list and, using Kartesz and Meacham (1999) and Thomas and Allen (1993–1998), determined their distribution by state or region across North America north of Mexico (see MacRoberts & MacRoberts 2003b for method). On the basis of this and other phytogeographical information, we developed a thematic map of the floristic affinities between Caddo Parish and the remainder of North America.

Rare plants often indicate rare habitat and vice versa. Using the Louisiana rare plant list (Louisiana Natural Heritage Program 2006), we listed all rare plants found in Caddo Parish and their primary habitat. We then summarized these data by habitat. Regionally endemic plants also indicate unique habitat, as do singularities. Because Caddo Parish is in the center of the West Gulf Coastal Plain, we used a list of endemics in that region to determine how many occur in Caddo Parish and with which community they are associated (M.H. MacRoberts et al. 2002). Additionally, Louisiana plant species that occur only in Caddo Parish were determined using the Louisiana Natural Heritage Program (2006) rare plant list and Thomas and Allen (1993–1998). We listed these and their associated habitats.

RESULTS AND DISCUSSION

We documented 1405 species in Caddo Parish (1168 native and 237 non-native). The vouchered checklist of the vascular plants of Caddo Parish is given after the discussion. Figure 3 gives the results of the phytogeographic analysis of Caddo Parish species. Table 1 gives Caddo Parish rare plants/plant community associations. Table 2 gives West Gulf Coastal Plain endemic species/community associations that occur in Caddo Parish. Table 3 lists the Louisiana native species found only in Caddo Parish with their associated communities.

The figure of 1405 species for Caddo Parish is higher than that for most parishes and counties of similar size throughout the southeastern United States (e.g., Nesom & Brown 1998; Leidolf et al. 2002; Neyland 2002; Marsico 2005). However, Caddo Parish has been better collected than most parishes and counties and additional collecting would bring up their species counts.

North America north of Mexico has approximately 19,000 vascular plant species (Thorne 1993; Kartesz & Meacham 1999). Caddo Parish has 7.4 percent of this total but constitutes only 0.01 percent of the land area. Likewise, while Caddo Parish constitutes only about 1 percent of the land area of the West Gulf Coastal Plain, it contains about 36 percent of the West Gulf Coastal Plain flora.

The Caddo Parish flora is eastern and specifically southeastern. Caddo Parish shares 99 percent of its flora with Texas, 98 percent with the remainder of Louisiana, 98 percent with Arkansas, 91 percent with Mississippi and Alabama, 88 percent with Oklahoma, 50

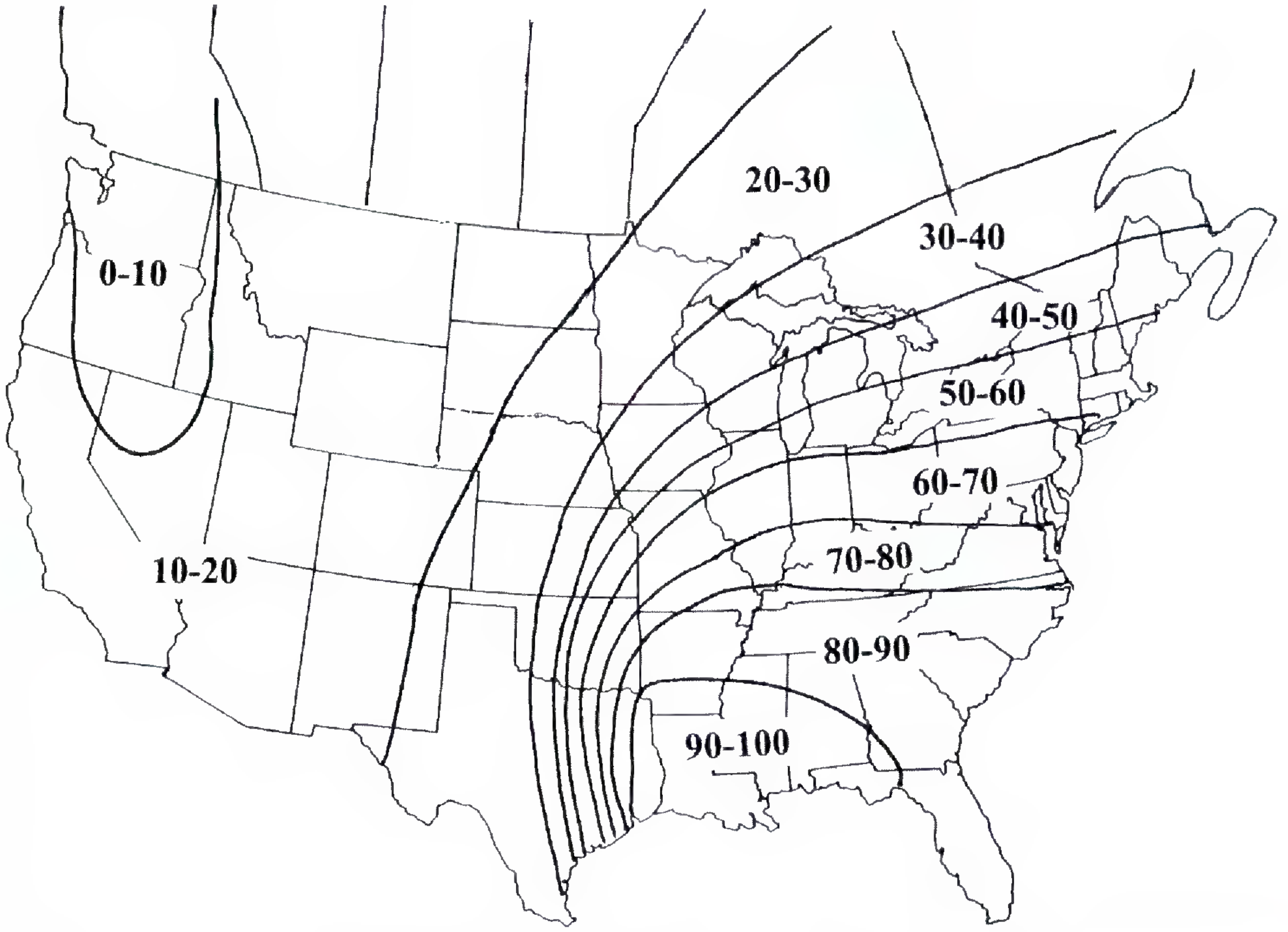


FIG. 3. The North American distribution as percent of total species of Caddo Parish plants shown thematically.

percent with the New England states, but only 21 percent with New Mexico. While Caddo Parish has 99 percent of its flora in common with Texas, there is a sharp transition zone across Texas in which eastern species drop out and are replaced by western species (MacRoberts & MacRoberts 2003b). The transition is much less dramatic to the north and east. This pattern is also shown in McLaughlin (in press).

Thirty-six percent of the Louisiana rare species listed by the Louisiana Natural Heritage Program (2006) for Caddo Parish are essentially specific to one community: xeric sandylands (MacRoberts & MacRoberts 1995; B.R. MacRoberts et al. 2002). The next ranked community for rare species for Caddo Parish is calcareous prairie with 16 percent (MacRoberts et al. 2003) and saline prairie with 14 percent, followed by pine-hardwood forest with 11 percent (Larke & Smith 1994). The remaining 23 percent of rare species are spread among six plant communities.

Caddo Parish has 45 of the approximately 100 West Gulf Coastal Plain endemic taxa (MacRoberts et al. 2002), of which 64 percent are associated with xeric sandylands. The next highest communities for endemics are baygalls and calcareous prairies with 9 and 7 percent, respectively. The remainder of endemics are spread among five communities.

Of the 15 native Louisiana species occurring only in Caddo Parish, 8 occur in xeric sandylands, once again pinpointing this habitat/community as unique.

Since two communities account for the majority of rare and endemic species in Caddo Parish, perhaps some comments on these communities is desirable.

Xeric sandylands are found in eastern Texas, southeastern Oklahoma, southwestern Arkansas, and western Louisiana (McBryde 1933; MacRoberts & MacRoberts 1994, 1995,

TABLE 1. Rare plants/community associations for Caddo Parish.

Community	Number of Rare Plants	Percentage
Xeric sandyland	27	36
Calcareous Prairie	12	16
Saline Prairie	10	14
Pine-Hardwood Forest	8	11
Calcareous Forest	5	7
Baygall	3	4
Swamp	3	4
Small Stream Forest	2	3
Batture Forest	1	1
Unknown	3	4
Total	74	100

TABLE 2. Endemic West Gulf Coastal Plain plant species with community associations for Caddo Parish.

Community	Number of Endemic Plants	Percentage
Xeric sandyland	29	64
Baygall	4	9
Calcareous Prairie	3	7
Pine-Hardwood Forest	2	4
Floodplain/Bottomland	2	4
Mayhaw Pond	2	4
Small Stream Forest	1	2
Barrens	1	2
Unknown	1	2
Total	45	100

1996, 1997; B.R. MacRoberts et al. 2002; Diggs et al. 2006). They are open to sparsely wooded areas that typically occur on terraces or ridges composed of deep sands, generally of marine Tertiary origin. Water and air move through these sands creating a dry, desert-like environment. Soils, where undisturbed, are often cryptogamic. Lichens (e.g., *Cladonia* spp.) may be common. *Quercus incana* is common, but stunted *Q. stellata* and *Q. margarettiae* are also present. Other characteristic species include *Bulbostylis ciliatifolia, Cnidoscolus texanus, Coreopsis intermedia, Croton argyranthemus, Eriogonum longifolium, E. multifolium, Froelichia floridana, Hymenopappus artemisiifolius, Matelea cynanchoides, Mirabilis albida, Opuntia humifusa, Paronychia drummondii, Pediomelum digitatum, P. hypogaeum, Penstemon murrayanus, Phlox drummondii, Polygonella americana, Selaginella arenicola, Streptanthus hyacinthoides, Talinum rugospermum, Tetragonotheca ludoviciana, Thelesperma filifolium, Tradescantia reverchonii, Yucca louisianensis*, and *Zornia bracteata*. Floristic richness is high in this community. Although widespread, xeric sandylands are not a dominant community across the West Gulf Coastal Plain and are generally found in relatively small patches. At the time of European settlement, it has been estimated that xeric sandylands accounted for less than one percent of western Louisiana (Lester et al. 2005) and, although there are no published figures, probably much less than this in either Oklahoma or Arkansas. In Texas,

TABLE 3. Native Louisiana species found only in Caddo Parish with community associations.

Agalinis caddoensis (community unknown)
Callirhoe digitata (prairie?)
Callirhoe involucrata (prairie?)
Carex arkansana (upland forest, roadside, saline prairie?)
Coreopsis intermedia (xeric sandyland)
Dalea phleoides (xeric sandyland)
Dasistoma macrophylla (mixed pine-hardwood forest)
Helianthemum rosmarinifolium (mima mounds in saline prairie)
Loeflingia squarrosa (xeric sandyland)
Matelea cynanchoides (xeric sandyland)
Pediomelum digitatum (xeric sandyland)
Prunus gracilis (xeric sandyland)
Talinum rugospermum (xeric sandyland)
Thelesperma filifolium (xeric sandyland)
Trillium pusillum (baygall)

especially along the Carrizo formation, xeric sandylands were common, but for the whole of this region this community is unlikely to have amounted to more than 5 percent of the area. Today, most xeric sandylands have been destroyed. Again figures are not available, but probably less than 5 to 10 percent of the original remain in any natural condition. Most of this community has been converted to pine plantations, grazing land, and watermelon patches. In Caddo Parish, it is decidedly rare and is found only in the northern part of the parish near Mira, Ida, Rodessa, and Vivian. Over the last twenty years, we have watched considerable acreage of this community vanish under cultivation, urban sprawl, and habitat deterioration caused by fire suppression (MacRoberts & MacRoberts 1995, 1998). Generally speaking, therefore, it represents a minor community by area but is an important community because of endemism and locally rare species.

Calcareous prairies were once widespread across the West Gulf Coastal Plain (MacRoberts et al. 2003; MacRoberts & MacRoberts 2004a; Lester et al. 2005). Virtually none of this community is left today and none in Caddo Parish although prairies were once fairly common not only in the uplands, but on the floodplain as well (MacRoberts et al. 1997; MacRoberts & MacRoberts 2004b). While prairies were common in central Texas (Diggs et al. 1999), far less than one percent of Louisiana (or Caddo Parish) was ever prairie land (MacRoberts et al. 2003; MacRoberts & MacRoberts 2004a). Today, Louisiana prairies can be counted only in the tens to hundreds of hectares.

Another community that deserves mention because of its rareness is saline prairie. This community occurs in several places in the West Gulf Coastal Plain (McInnis et al. 1993; Keith et al. 2004; Lester et al. 2005). It has received some attention because *Geocarpon minimum*, which is listed as federally threatened, occurs in it. In Caddo Parish, there are two known saline prairies. One, about 0.5 ha, was discovered by Overby (1974); the other, a prairie of 11 ha, was found in 2005 by C. Reid of the Louisiana Natural Heritage Program (Barron Road Saline Prairie). Overby found *Talinum parviflorum* in the prairie she located. We examined the Overby prairie several times, and relocated *Talinum*, but the last time we visited the site in March 2006, it had nearly been destroyed by all-terrain vehicles (ATVs). Barron Road Prairie is also damaged by ATVs.

Saline prairie is mostly treeless (mima mounds may be present), with many open soil areas known as "slicks" with cryptogamic, high sodium soils, and sparse vegetation.

Characteristic plants include *Anagallis minima*, *Claytonia virginica*, *Crassula aquatica*, *Eragrostis lugens*, *Evolvulus sericeus*, *Houstonia micrantha*, *Houstonia pusilla*, *Houstonia rosea*, *Krigia occidentalis*, *Lepuropetalon spathulatum*, *Plantago pusilla*, and *Sporobolus vaginiflorus*. Ten Louisiana and one globally rare species have been located at the Barron Road Saline Prairie. These are *Cooperia drummondii*, *Geocarpon minimum*, *Gratiola flava*, *Helianthemum rosmarinifolium*, *Lotus unifoliolatus*, *Minuartia drummondii*, *Minuartia muscorum*, *Phacelia glabra*, *Schoenolirion wrightii*, and *Talinum parviflorum*.

The two surviving plant collections from the 1806 Freeman-Custis' Red River Expedition are *Eustoma russellianum* (Hook.) G. Don and *Veronicastrum virginicum* (L.) Farw. (Flores 1984; MacRoberts & MacRoberts 2004b). *Eustoma russellianum* does not occur anywhere in the region today, and *Veronicastrum virginicum* is very rare in the region and has not been found in Caddo or Bossier parishes since Custis' original collection. We have noted this same pattern with subsequent early collectors in the area. Pennell found the only species endemic to Caddo Parish—*Agalinis caddoensis*—near Shreveport in 1913; it has not been found since. Hale, Cocks, Peterson, Correll, Palmer, and other early collectors found species in the area that are either very rare today or entirely missing (e.g., *Buchloe dactyloides*, *Dasistoma macrophylla*, *Gratiola flava*, *Helianthus occidentalis*, *Helianthus petiolaris*, *Onosmodium bejariense*, *Panicum flexile*, *Prosopis glandulosis*, *Sophora affinis*, and *Taenidia integerrima*). This suggests that in the last two centuries, a great deal of the original habitat has been lost and that the flora was once richer in native species than it is today.

VOUCHERED CHECKLIST OF VASCULAR PLANTS

The following is a vouchered list of the vascular plants for Caddo Parish. We list one voucher for each species. Key to vouchers: **DTM** = D.T. MacRoberts. Unless otherwise stated, his specimens are at LSUS. **RDT** = R. Dale Thomas. Unless otherwise stated, his specimens are at NLU. **MM** = B.R. and M.H. MacRoberts. Unless otherwise stated, their specimens are at LSUS. **Raymond** = Larry R. Raymond. The herbarium where his specimens are located is always given. **Hardy** = L.M. Hardy. His specimens are at LSUS. **Haynes** = Robert Haynes. His specimens are at LSUS. **Barbour** = Philip Barbour. His specimens are at LSUS unless otherwise stated. Other collectors are given full citations. An * (asterisk) indicates a non-native species.

PTERIDOPHYTES

ASPLENIACEAE

Asplenium platyneuron (L.) B.S.P.; DTM 829

AZOLLACEAE

Azolla caroliniana Willd.; MM 5935

BLECHNACEAE

Woodwardia areolata (L.) T. Moore; DTM 1546
Woodwardia virginica (L.) Sm.; RDT 33699

DENNSTAEDTIACEAE

Pteridium aquilinum (L.) Kuhn; DTM 898

DRYOPTERIDACEAE

Athyrium filix-femina (L.) Roth; DTM 1221
**Cyrtomium falcatum* (L.f.) K. Presl; DTM 113 (questionably naturalized)
Onoclea sensibilis L.; DTM 950
Polystichum acrostichoides (Michx.) Schott; DTM 2197
Woodsia obtusa (Spreng.) Torr.; DTM 835

EQUISETACEAE

Equisetum hyemale L.; Barbour 932
Equisetum ×ferrissii Clute; DTM 1700

ISOETACEAE

Isoetes melanopoda Gay & Durieu ex Durieu; RDT 89029

LYGODIACEAE

**Lygodium japonicum* (Thunb. ex Murr.) Sw.; DTM 1090

OPHIOGLOSSACEAE

Botrychium biternatum (Sav.) Underwood; DTM 2012
Botrychium dissectum Spreng.; Raymond 1600 NLU
Botrychium lunarioides (Michx.) Sw.; RDT 148118
Botrychium virginianum (L.) Sw.; DTM 2222
Ophioglossum crotalophoroides Walt.; MM 6062

Ophioglossum engelmannii Prantl; RDT 34526 LSU
Ophioglossum nudicaule L.f.; RDT 51996
Ophioglossum petiolatum Hook.; RDT 33845 LSU
Ophioglossum vulgatum L.; MM 154

OSMUNDACEAE
Osmunda cinnamomea L.; DTM 2156
Osmunda regalis L.; DTM 2157

POLYPODIACEAE
Pleopeltis polypodioides (L.) Andrews & Windham; DTM 949

SELAGINELLACEAE
Selaginella arenicola Underwood; MM 2840

THELYPTERIDACEAE
Thelypteris kunthii (Desv.) Morton; DTM 1734
Thelypteris palustris Schott; DTM 1212

GYMNOSPERMS

CUPRESSACEAE
Juniperus virginiana L.; DTM 1609
Taxodium distichum (L.) L.C. Rich.; MM 6514

PINACEAE
Pinus echinata P. Mill.; MM 6199
Pinus taeda L.; MM 5982

ANGIOSPERMS

MONOCOTYLEDONS

AGAVACEAE
Manfreda virginica (L.) Salisb. ex Rose; DTM 1861
Yucca louisianensis Trel.; MM 241

ALISMATACEAE
Echinodorus cordifolius (L.) Griseb.; DTM *77*
Sagittaria graminea Michx.; DTM 1315
Sagittaria latifolia Willd.; DTM 672
**Sagittaria montevidensis* Cham. & Schlecht.; DTM 1590
Sagittaria papillosa Buch.; DTM 1300
Sagittaria platyphylla (Engelm.) J.G. Sm.; DTM 1216

ARACEAE
Arisaema dracontium (L.) Schott; DTM 377
Arisaema triphyllum (L.) Schott; DTM 2153
**Colocasia esculenta* (L.) Schott; DTM 1306
Peltandra virginica (L.) Schott; DTM 2224

ARECACEAE
Sabal minor (Jacq.) Pers.; MM 190

BROMELIACEAE
Tillandsia usneoides (L.) L.; DTM 3002

BURMANNIACEAE
Burmannia biflora L.; Reid 4639 LSU (Reid, pers. comm.)

CANNACEAE
**Canna indica* L.; DTM 1855 (questionably naturalized)

COMMELINACEAE
**Commelina communis* L.; DTM 2329
Commelina diffusa Burm. f.; DTM 1408
Commelina erecta L.; DTM 141
Commelina virginica L.; DTM 486
Tradescantia hirsutiflora Bush; DTM 855
Tradescantia occidentalis (Britt.) Smyth; DTM 473
Tradescantia ohiensis Raf.; DTM 1693
Tradescantia reverchonii Bush; DTM 1715

CYPERACEAE
Bulbostylis capillaris (L.) Kunth ex C.B. Clarke; RDT 155761
Bulbostylis ciliatifolia (Ell.) Fern.; MM 2833
Carex albicans Willd. ex Spreng.; Raymond 1722 NLU
Carex albolutescens Schwein.; Hyatt 8580 LSU
Carex arkansana (Bailey) Bailey; Thieret 25936 LAF
Carex atlantica Bailey; RDT 95343 LSU
Carex austricina Mackenzie; RDT 99527
Carex blanda Dewey; RDT 170061
Carex caroliniana Schwein; MM 7389
Carex cherokeensis Schwein.; DTM 1736
Carex complanata Torr. & Hook.; Barbour 990
Carex crebriflora Wieg.; Raymond 1234 NLU
Carex crinita Lam.; DTM 2231
Carex crus-corvi Shuttlew. ex Kunze; DTM 1353
Carex debilis Michx.; RDT 95345
Carex decomposita Muhl.; MM 7429
Carex festucacea Schkuhr ex Willd.; Thieret 22620 LAF
Carex flaccosperma Dewey; Raymond 1213 LSUS
Carex frankii Kunth; DTM 1281
Carex glaucescens Ell.; Raymond 1359 LSU
Carex glaucoidea Tuckerman ex Olney; RDT 99544
Carex hyalina Boott; MM 3126
Carex hyalinolepis Steud.; Raymond 1430 NLU
Carex intumescens Rudge; Barbour 979
Carex joorii Bailey; RDT 167047
Carex leavenworthii Dewey; MM 6021
Carex leptalea Wahl.; Reid 4864 LSU (Reid, pers. comm.)
Carex louisianica Bailey; DTM 1237
Carex lupulina Muhl. ex Willd.; DTM 2352
Carex lurida Wahlenb.; DTM 1236
Carex meadii Dewey; MM 2525
Carex muehlenbergii Schkuhr ex Willd.; RDT 88719
Carex nigromarginata Schwein.; Haynes 5697
Carex oxylepis Torr. & Hook.; Barbour 983
Carex planispicata Naczi; Raymond 1677 NLU
Carex reniformis (Bailey) Small; Raymond 1214 NLU
Carex retroflexa Muhl. ex Willd.; MM 6174
Carex styloflexa Buckl.; DTM 1640
Carex texensis (Torr.) Bailey; RDT 88223
Carex triangularis Boeckl.; RDT 99524
Carex tribuloides Wahlenb.; RDT 170062
Carex vulpinoidea Michx.; DTM 1349
Cyperus acuminatus Torr. & Hook. ex Torr.; DTM 2332
Cyperus compressus L.; RDT 32983
Cyperus croceus Vahl; MM 6834

Cyperus difformis L.; MM 6993
Cyperus echinatus (L.) Wood.; DTM 1931
Cyperus erythrorhizos Muhl.; Haynes 5430
Cyperus esculentus L.; MM 6857
Cyperus filiculmis Vahl; RDT 170174 (Ferguson, pers. comm.)
Cyperus flavescens L.; C.E. DePoe 6652-1 NLU (Ferguson, pers. comm.)
Cyperus flavicomus Michx.; Shireman 57 LSU
Cyperus iria L.; DTM 1444
Cyperus odoratus L.; MM 6983
Cyperus oxylepis Nees ex Steud.; RDT 37207
Cyperus plukenetii Fern.; Lynch 2639 LSUS
Cyperus polystachyos Rottb.; Lynch 2674 LSUS
Cyperus. pseudovegetus Steud.; RDT 166992 (Ferguson, pers. comm.)
Cyperus retroflexus Buckl.; MM 2725
Cyperus retrorsus Chapm.; MM 6630
Cyperus rotundus L.; DTM 1361
Cyperus strigosus L.; RDT 45424 (Ferguson, pers. comm.)
Cyperus virens Michx.; Overby 85 NLU (Ferguson, pers. comm.)
Eleocharis acicularis (L.) Roemer & J.A. Schultes; DTM 1458
Eleocharis obtusa (Willd.) J.A. Schultes; DTM 1238
Eleocharis palustris (L.) Roemer & J.A. Schultes; MM 6429
Eleocharis parvula (Roemer & J.A. Schultes) Link; Barbour 498
Eleocharis tortilis (Link) J. A. Schultes; RDT 33624
Eleocharis tuberculosa (Michx.) Roemer & J.A. Schultes; RDT 36268
Fimbristylis autumnalis (L.) Roemer & J.A. Schultes; DTM 1567
Fimbristylis miliacea (L.) Vahl; DTM 1542
Fimbristylis puberula (Michx.) Vahl; Raymond 2147 LSUS
Fimbristylis tomentosa Vahl; DTM 1528
Fimbristylis vahlii (Lam.) Link; DTM 1512
Fuirena simplex Vahl; MM 6673
Fuirena squarrosa Michx.; RDT 140688
Isolepis carinata Hook. & Arn. ex Torr.; DTM 2829
Isolepis molesta (M.C. Johnston) S.G. Sm.; Shinners 28087 BRIT
Kyllinga brevifolia Rottb.; DTM 1928
Kyllinga odorata Vahl; DTM 1314
Kyllinga pumila Michx.; RDT 32974
Lipocarpha micrantha (Vahl) G. Tucker; Shireman 56 LSU
Rhynchospora caduca Ell.; Raymond 2028 LSUS
Rhynchospora corniculata (Lam.) A. Gray; DTM 1113
Rhynchospora glomerata (L.) Vahl; Barbour 494
Rhynchospora harveyi W. Boott; MM 7427
Rhynchospora inexpansa (Michx.) Vahl; Haynes 5352
Scirpus atrovirens Willd.; Allen 7975 NO
Scirpus cyperinus (L.) Kunth; DTM 1448
Scleria ciliata Michx.; RDT 11904
Scleria oligantha Michx.; Allen 3766 LAF
Scleria pauciflora Muhl. ex Willd.; Allen 9879 LAF
Scleria triglomerata Michx.; RDT 92403
Websteria confervoides (Poir.) S. Hooper; Barbour 495 LSU

DIOSCOREACEAE

Dioscorea villosa L.; DTM 1288

HYDROCHARITACEAE

Egeria densa Planch.; Barbour 483
Limnobium spongia (Bosc) L.C. Rich. ex Steud.; Haynes 5342

IRIDACEAE

Alophia drummondii (Graham) R.C. Foster; DTM 1762
Herbertia lahue (Molina) Goldblatt; MM 198
Iris brevicaulis Raf.; Raymond 2094 LSUS
Iris fulva Ker-Gawl.; French s.n. NLU
Iris giganticaerulea Small; Overby 192 NLU
Iris pallida Lam.; Laborde 44 LSUS
Iris pseudacorus L.; MM 172
Iris virginica L.; DTM 2291
Nemastylis geminiflora Nutt.; DTM 369
Sisyrinchium angustifolium P. Mill.; DTM 415
Sisyrinchium atlanticum Bickn.; DTM 340
Sisyrinchium langloissii Greene; MM 2558
Sisyrinchium minus Engelm. & A. Gray; Thieret 25939 LAF
Sisyrinchium rosulatum Bickn.; DTM 866

JUNCACEAE

Juncus acuminatus Michx.; RDT 81369
Juncus brachycarpus Engelm.; DTM 1112
Juncus bufonius L.; MM 6445
Juncus capitatus Weigel; RDT 128670 LSU
Juncus coriaceus Mackenzie; DePoe 6650 NLU
Juncus dichotomus Ell.; DTM 1272
Juncus diffusissimus Buckl.; DTM 1234
Juncus dudleyi Wieg.; RDT 81373
Juncus effusus L.; DTM 1244
Juncus marginatus Rostk.; DTM 1235
Juncus nodatus Coville; Raymond 1241 NLU
Juncus polycephalus Michx.; RDT 629
Juncus repens Michx.; RDT 136859
Juncus scirpoides Lam.; RDT 33633
Juncus tenuis Willd.; DTM 1163
Juncus torreyi Coville; RDT 128675
Juncus validus Coville; DTM 1269
Luzula bulbosa (Wood) Smyth & Smyth; Haynes 4568

LEMNACEAE

Lemna aequinoctialis Welw.; Overby 86 NLU
Lemna minor L.; Haynes 4220
Lemna valdiviana Phil.; Haynes 4157
Spirodela polyrrhiza (L.) Schleid.; Haynes 4155
Spirodela punctata (G.F.W.Mey.) C.H. Thompson; Haynes 4221
Wolffia brasiliensis Weddell; Haynes 4154
Wolffia columbiana Karst.; Overby 227 NLU
Wolffiella gladiata (Hegelm.) Hegelm.; Haynes 4153

LILIACEAE

Allium canadense L.; DTM 3058
**Asparagus officinalis* L.; MM s.n (questionably naturalized).
Camassia scilloides (Raf.) Cory; DTM 3015
Cooperia drummondii Herbert; MM 2914
Erythronium albidum Nutt.; DTM 2126
Habranthus tubispathus (L'Her.) Traub.; MM 262
**Hemerocallis fulva* (L.) L.; DTM 1723 (localized and persisting)
Hymenocallis caroliniana (L.) Herbert; DTM 1843
Hymenocallis liriosome (Raf.) Shinners; DTM 853
Hypoxis hirsuta (L.) Coville; DTM 343 (includes *H. rigida* Chapman)
**Narcissus pseudonarcissus* L.; Barbour 559 (localized and persisting)
Nothoscordum bivalve (L.) Britt.; DTM 250
**Nothoscordum inodorum* (Aiton) Nichols; DTM 1675
**Ornithogalum umbellatum* L.; DTM 3014
Polygonatum biflorum (Walt.) Ell.; DTM 674
Schoenolirion wrightii Sherman; MM 7291
Stenanthium gramineum (Ker-Gawl.) Morong; DTM 1811
Trillium recurvatum Beck; MM 144
Trillium pusillum Michx.; DTM 2185
Uvularia sessilifolia L.; DTM 2617
**Zephryanthes candida* (Lindl.) Herbert; Barbour 467
Zigadenus nuttallii (Gray) S. Wats.; DTM 861

NAJADACEAE

Najas guadalupensis (Spreng.) Magnus; DTM 1522

ORCHIDACEAE

Corallorhiza wisteriana Conrad; DTM 1123
Habenaria repens Nutt.; Raymond 1947 LSUS
Isotria verticillata Raf.; DTM 2281
Listera australis Lindl.; DTM 2162
Malaxis unifolia Michx.; RDT 43537
Platanthera ciliaris (L.) Lindl.; RDT 42439
Platanthera clavellata (Michx.) Luer; MM 256
Platanthera flava (L.) Lindl.; Raymond 1483 NLU
Platanthera lacera (Michx.) G. Don; DTM 1759
Spiranthes cernuus (L.) L.C.Rich.; MM 278
Spiranthes lacera (Raf.) Raf.; Overby 262 NLU
Spiranthes laciniata (Small) Ames; DTM 2013
Spiranthes odorata (Nutt.) Lindl.; Haynes 5426
Spiranthes ovalis Lindl.; DTM 1856
Spiranthes praecox (Walt.) S. Wats.; DTM 2313 LSU
Spiranthes tuberosa Raf.; DTM 546
Spiranthes vernalis Engelm. & A. Gray; DTM 903
Tipularia discolor (Pursh) Nutt.; Givens 3557 LSU
Triphora trianthophora (Sw.) Rydb.; Raymond 1529 NLU

POACEAE

Agrostis elliottiana J.A. Schultes; DTM 1632
**Agrostis gigantea* Roth; DTM 1268
Agrostis hyemalis (Walt.) B.S.P.; DTM 2029
Agrostis perennans (Walt.) Tuckerman; DTM 1416
Agrostis stolonifera L.; DTM 1309
**Aira caryophyllea* L.; DTM 3059
**Aira elegans* Willd. ex Kunth; DTM 1659
Alopecurus carolinianus Walt.; DTM 2603
Andropogon gerardii Vitman; DTM 1458
Andropogon glomeratus (Walt.) B.S.P.; DTM 1498
Andropogon ternarius Michx.; DTM 1534
Andropogon virginicus L.; DTM 1483
**Anthoxanthum aristatum* Boiss.; DTM 1742
Aristida desmantha Trin. & Rupr.; MM 2892
Aristida dichotoma Michx.; DTM 2004
Aristida lanosa Muhl. ex Ell.; MM 2928
Aristida longespica Poir.; DTM 1563
Aristida oligantha Michx.; MM 2893
Aristida purpurascens Poir.; DTM 1468
Arundinaria gigantea (Walt.) Muhl.; DTM 2193
**Arundo donax* L.; DTM 1569
**Avena fatua* L.; DTM 1732
**Avena sativa* L.; DTM 2615
Axonopus fissifolius (Raddi) Kuhlm.; DTM 1264
**Bothriochloa ischaemum* (L.) Keng; RDT 68561
Bothriochloa languroides (DC.) Herter; DTM 1382
Bothriochloa longipaniculata (Gould) Allred & Gould; DTM 2079
Bothriochloa springfieldii (Gould) Parodi; Thieret 24481 LAF
**Briza minor* L.; DTM 1656
**Bromus catharticus* Vahl; DTM 2298
**Bromus diandrus* Roth; RDT 65106 LSU
**Bromus japonicus* Thunb. ex Murr.; DTM 1321
**Bromus lanceolatus* Roth; DTM 1770
Bromus pubescens Muhl. ex Willd.; DTM 1688
**Bromus racemosus* L.; DTM 1699
**Bromus secalinus* L.; DTM 1322
**Bromus tectorum* L.; DTM 2192
Buchloe dactyloides (Nutt.) Engelm.; Snyder s.n.US
Cenchrus spinifex Cav.; MM 2813
Chasmanthium latifolium (Michx.) Yates; DTM 1735
Chasmanthium laxum (L.) Yates; DTM 1384
Chasmanthium sessiliflorum (Poir.) Yates; DTM 2557
Chloris virgata Sw.; DTM 1320
**Cynodon dactylon* (L.) Pers.; Haynes 4237
**Cynosurus echinatus* L.; DTM 1773
**Dactylis glomerata* L.; DTM 1816
**Dactyloctenum aegyptium* (L.) Willd.; Overby 121 NLU
Danthonia spicata (L.) Beauv. ex Roemer & J.A. Schultes; DTM 1655
Dichanthelium aciculare (Desv. ex Poir.) Gould & C.A. Clark; DTM 1671
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark; DTM 1210.
Dichanthelium boscii (Poir.) Gould and C.A. Clark; DTM 1408
Dichanthelium commutatum (J.A. Schultes) Gould; DTM 1241

Dichanthelium depauperatum (Muhl.) Gould; Lewis 3490 NLU
Dichanthelium dichotomum (L.) Gould; DTM 1182
Dichanthelium laxiflorum (Lam.) Gould; DTM 1239
Dichanthelium linearifolium (Scribn.ex Nash) Gould; Allen 5062 LAF
Dichanthelium oligosanthes (J.A. Schultes) Gould; MM 2617
Dichanthelium ovale (Ell.) Gould & C.A. Clark; Lewis 3585 NLU
Dichanthelium polyanthes Schult.; MM 6491
Dichanthelium ravenelii (Scribn. & Merr.) Gould; DTM 1375
Dichanthelium scoparium (Lam.) Gould; DTM 1403
Dichanthelium sphaerocarpon (Ell.) Gould; DTM 1274
Digitaria ciliaris (Retz.) Koel.; DTM 1414
Digitaria cognata (J.A. Schultes) Pilger; DTM 1527
Digitaria filiformis (L.) Koel.; DTM 1544
**Digitaria ischaemum* (Schreb.) Schreb. ex Muhl.; DTM 1518
**Digitaria violascens* Link; DTM 1379
**Echinochloa colona* (L.) Link; DTM 1231
**Echinochloa crus galli* (L.) Beauv.; Brooks 277 LSU
Echinochloa muricata (Beauv.) Fern.; MM 6854
Echinochloa walteri (Pursh) Heller; DTM 2553
**Eleusine indica* (L.) Gaertn.; DTM 1596
Elymus virginicus L.; DTM 2999
**Eragrostis cilianensis* (All.) Vign. ex Janchen.; DTM 1420
**Eragrostis curvula* (Schrad.) Nees; DTM 2312
Eragrostis hirsuta (Michx.) Nees; MM 2927
Eragrostis hypnoides (Lam.) B.S.P.; DTM 1479
**Eragrostis japonica* (Thunb.) Trin; DTM 2706
Eragrostis lugens Nees; DTM 1643
**Eragrostis minor* Host; DTM 1377
**Eragrostis pilosa* (L.) Beauv.; DTM 1510
Eragrostis refracta (Muhl.) Scribn.; DTM 1997
Eragrostis reptans (Michx.) Nees; DTM 1986
Eragrostis secundiflora J.Presl; DTM 1803
Eragrostis spectabilis (Pursh) Steud.; MM 2917
Eragrostis trichodes (Nutt.) Wood; MM 2918
**Eremochloa ophiuroides* (Monro) Hack.; DTM 1363
Eriochloa acuminata (J. Presl) Kunth; DTM 1971
Eriochloa contracta A.S. Hitchc.; DTM 1481
Festuca paradoxa Desv.; DTM 1277
Glyceria arkansana Fern.; DTM 2327
Gymnopogon ambiguus (Michx.) B.S.P.; DTM 1489
**Holcus lanatus* L.; DTM 1346
Hordeum pusillum Nutt.; DTM 1621
Leersia lenticularis Michx.; Haynes 5422
Leersia oryzoides (L.) Sw.; DTM 1488
Leersia virginica Willd.; DTM 1359
Leptochloa fusca (L.) Kunth; DTM 1325
Leptochloa panicea (Retz.) Ohwi; MM 6767
Leptochloa panicoides (J. Presl) A.S. Hitchc.; DTM 1985
**Lolium arundinaceum* (Schreb.) S.J. Derbyshire; DTM 1391
**Lolium perenne* L.; DTM 1187
**Lolium temulentum* L.; DTM 1673
Luziola fluitans (Michx.) Terrell & Robins.; DTM 1549
Melica mutica Walt.; DTM 1614
Muhlenbergia schreberi J.F. Gmel.; DTM 1424
Nassella leucotricha (Trin. & Rupr.) Pohl; DTM 3050
Oplismenus hirtellus (L.) Beauv.; DTM 1305
Panicum anceps Michx.; DTM 1335
Panicum brachyanthum Steud.; DTM 1998
Panicum capillare L.; DTM 1511
Panicum dichotomiflorum Michx.; DTM 1386
Panicum flexile (Gattinger) Scribn.; Correll & Correll 10097 LSU
Panicum gymnocarpon Ell.; Haynes 5425
Panicum hemitomon J.A. Schultes; RDT 140681
Panicum rigidulum Bosc. ex Nees; DTM 1395
Panicum verrucosum Muhl.; DTM 1529
Panicum virgatum L.; DTM 1413
**Paspalum dilatatum* Poir.; DTM 1191
Paspalum dissectum (L.) L.; Haynes 4089
Paspalum distichum L.; DTM 1970
Paspalum floridanum Michx.; DTM 1389
Paspalum laeve Michx.; DTM 1374
Paspalum langei (Fourn.) Nash; DTM 1366
**Paspalum notatum* Fluegge; DTM 1262
Paspalum plicatulum Michx.; DTM 1249
Paspalum pubiflorum Rupr. ex Fourn.; DTM 1586
Paspalum repens Berg.; RDT 32947
Paspalum setaceum Micnx.; DTM 1422
**Paspalum urvillei* Steud.; DTM 1240
Phalaris caroliniana Walt.; DTM 2628
**Phleum pratense* L.; RDT 65054
**Phyllostachys aurea* Carr ex A. Riv. & C. Riv.; MM 7244
Piptochaetium avenaceum (L.) Parodi; DTM 2297
**Poa annua* L.; DTM 1171
Poa autumnalis Muhl. ex Ell.; DTM 2186
Poa pratensis L.; Thieret 22666 LAF
**Polypogon monspeliensis* (L.) Desf.; RDT 66455 LSU
Saccharum alopecuroidum (L.) Nutt.; MM 2959
Saccharum baldwinii Spreng.; RDT 37271
Saccharum brevibarbe (Michx.) Pers.; DTM 1469
Saccharum giganteum (Walt.) Pers.; DTM 1536
Sacciolepis striata (L.) Nash; DTM 1431
Schedonnardus paniculatus (Nutt.) Trel.; DTM 2627
Schizachyrium scoparium (Michx.) Nash; DTM 1533
**Secale cereale* L.; DTM 2232
**Setaria faberi* Herrm.; RDT 119026
Setaria parviflora (Poir.) Kerguelen; MM 2055
**Setaria pumila* (Poir.) Roemer & J.A. Schultes; DTM 1573
**Setaria viridis* (L.) Beauv.; RDT 45434
Sorghastrum elliottii (Mohr) Nash; MM 2931
Sorghastrum nutans (L.) Nash; DTM 2005
**Sorghum bicolor* (L.) Moench; DTM 1411
**Sorghum halepense* (L.) Pers.; Haynes 4228
Sphenopholis intermedia (Rydb.) Rydb.; RDT 88229
Sphenopholis nitida (Biehler) Scribn.; DTM 1626

Sphenopholis obtusata (Michx.) Scribn.; DTM 2632
Sporobolus clandestinus (Biehler) A.S. Hitchc.; RDT 37044
Sporobolus compositus (Poir) Merr.; DTM 1579
Sporobolus cryptandrus (Torr.) A. Gray; DTM 1578
Sporobolus indicus (L.) R.Br.; DTM 1922
Sporobolus junceus (Beauv.) Kunth; DTM 1515
Sporobolus pyramidatus (Lam.) Hitchc.; MM 7277
Sporobolus vaginiflorus (Torr.ex Gray) Wood; RDT 37396 LSU
Steinchisma hians (Ell.) Nash; DTM 1745
Stenotaphrum secundatum (Walt.) Kuntze; DTM 1308
Tridens ambiguus (Ell.) J.A. Schultes; DTM 1473
Tridens flavus (L.) A.S.Hitchc.; MM 2915 (includes *Tridens chapmanii* (Small) Chase)
Tridens strictus (Nutt.) Nash; Raymond 1136 LSUS
Triplasis purpurea (Walt.) Chapman; MM 2932
Tripsacum dactyloides (L.) L.; DTM 1365
Trisetum interruptum Buckl.; Allen 3774 NLU
**Triticum aestivum* L.; DTM 2645
Urochloa platyphylla (Monro ex Wright) R.Webster; DTM 1378
**Urochloa ramosa* (L.) Nguyen; DTM 1362
Urochloa texana (Buckl.) R.Webster; Kalmback-Burkett Co. s.n. LSU
**Vulpia bromoides* (L.) S.F. Gray; DTM 1228
**Vulpia myuros* (L.) K.C. Gmel.; DTM 1650
Vulpia octoflora (Walt.) Rydb.; DTM 2226
Vulpia sciurea (Nutt). Henr.; MM 2537
Zizaniopsis miliacea (Michx.) Doell. & Aschers.; DTM 1158

PONTEDERIACEAE
**Eichhornia crassipes* (Mart.) Solms; DTM 240
Pontederia cordata L.; DTM 88

POTAMOGETONACEAE
Potamogeton nodosus Poir.; Barbour 519
Potamogeton pusillus L.; DTM 1521

SMILACACEAE
Smilax bona-nox L.; DTM 970
Smilax glauca Walt.; DTM 119
Smilax laurifolia L.; Gebelein 25 LSUS
Smilax rotundifolia L.; DTM 959
Smilax smallii Morong; RDT 155720
Smilax tamnoides L.; RDT 32815

SPARAGANIACEAE
Sparganium americanum Nutt.; DTM 1830

TYPHACEAE
Typha domingensis Pers.; DTM 1758
Typha latifolia L.; DTM 1299

XYRIDACEAE
Xyris caroliniana Walt.; Barbour 1099
Xyris jupicai L.C. Rich.; MM 263

DICOTYLEDONS

ACANTHACEAE
Dicliptera brachiata (Pursh) Spreng.; DTM 227
Justicia ovata (Walt.) Lindau; DTM 688
**Ruellia brittoniana* Leonard; RDT 42038
Ruellia caroliniensis (J.F. Gmel.) Steud.; DTM 64
Ruellia humilis Nutt.; DTM 87
Ruellia pedunculata Torr. ex Gray; DTM 447

ACERACEAE
Acer barbatum Michx.; RDT 166956
Acer negundo L.; Haynes 4146
Acer rubrum L.; Haynes 4583
Acer saccharinum L.; Clark 2 LSU
Acer saccharum Marsh.; Graham 417 LSUS

AIZOACEAE
Sesuvium maritimum (Walt.) B.S.P.; Thieret 26136 LAF
Trianthema portulacastrum L.; DTM 174

AMARANTHACEAE
**Alternanthera philoxeroides* (Mart.) Griseb.; DTM 84
Amaranthus albus L.; RDT 66465 LSU
Amaranthus arenicola I.M. Johnston; RDT 59959
Amaranthus hybridus L.; DTM 1967
Amaranthus palmeri S.Wats.; DTM 1964
**Amaranthus retroflexus* L.; RDT 76695
Amaranthus rudis Sauer; DTM 1965
Amaranthus spinosus L.; DTM 924
Amaranthus viridis L.; MM 6978
Froelichia floridana (Nutt.) Moq.; DTM 1793
Froelichia gracilis (Hook.) Moq.; RDT 76696

ANACARDIACEAE
Rhus aromatica Aiton; DTM 2181
Rhus copallinum L.; DTM 1924
Rhus glabra L.; RDT 33565
Toxicodendron radicans (L) Kuntze; Haynes 4140

ANNONACEAE
Asimina parviflora (Michx.) Dunal; RDT 80926
Asimina triloba (L.) Dunal; Hardy 8685

APIACEAE
Ammoselinum butleri (Enelm. ex S.Wats.) Coult. & Rose; RDT 88289
Bowelsia incana Ruiz & Pavon; RDT 127180
**Bupleurum rotundifolium* L.; RDT 76689
Chaerophllum tainturieri Hook.; DTM 287
**Ciclospermum leptophyllum* (Pers.) Sprague ex Britt.& Wilson; Haynes 5777
Cicuta maculata L.; Graham 575 LSUS
**Conium maculatum* L.; DTM 1009
Cryptotaenia canadensis (L.) DC.; RDT 25312
Cynoscadium digitatum DC.; DTM 1190
**Daucus carota* L.; DTM 649
Daucus pusillus Michx.; MM 2653
Eryngium hookeri Walp.; DTM 143
Eryngium prostratum Nutt. ex DC.; Haynes 4109

Eryngium yuccifolium Michx.; DTM 142
**Falcaria vulgaris* Bernh.; RDT 88299
Hydrocotyle ranunculoides L.f.; DTM 1097
Hydrocotyle umbellata L.; DTM 1787
Hydrocotyle verticillata Thunb.; DTM 75
Limnoscadium pinnatum (DC.) Mathias & Constance; DTM 478
Oxypolis rigidior (L.) Raf.; RDT 80922
Polytaenia nuttallii DC.; DTM 549
Ptilimnium capillaceum (Michx.) Raf.; DTM 1022
Ptilimnium costatum (Ell.) Raf.; RDT 128660
Ptilimnium nuttallii (DC.) Britt.; Raymond 770 LSUS
Sanicula canadensis L.; DTM 1040
Sanicula odorata (Raf.) K.M. Pryer & L.R. Phillippe; RDT 33075
Sanicula smallii Bickn.; RDT 170095
Spermolepis divaricata (Walt.) Raf. ex Ser.; DTM 2285
Spermolepis echinata (Nutt. ex DC.) Heller; Allen 7999 LAF
Spermolepis inermis (Nutt. ex DC.) Mathias & Constance; RDT 45421
Taenidia integerrima (L.) Drude; Cocks s.n. NO
**Torilis arvensis* (Huds.) Link; DTM 29
**Torilis nodosa* (L.) Gaertn.; DTM 1033
**Trepocarpus aethusae* Nutt. ex DC.; DTM 464
Zizia aurea (L.) W.D.J. Koch; Raymond 732 LSUS

APOCYNACEAE

Amsonia tabernaemontana Walt.; DTM 838
Apocynum cannabinum L.; MM 6969
Trachelosperma difforme (Walt.) A. Gray; DTM 454
**Vinca major* L.; Barbour 290
**Vinca minor* L.; RDT 33687

AQUIFOLIACEAE

Ilex ambigua (Michx.) Torr.; RDT 140651 LSU
Ilex decidua Walt.; Haynes 4093
Ilex opaca Aiton; Hardy 8616
Ilex vomitoria Aiton; DTM 1151

ARALIACEAE

Aralia spinosa L.; DTM 1154

ARISTOLOCHIACEAE

Aristolochia reticulata Jacq.; RDT 80871
Aristolochia serpentaria L.; RDT 119103
Aristolochia tomentosa Sims; RDT 36969

ASCLEPIADACEAE

Asclepias amplexicaulis Sm.; DTM 2294
Asclepias perennis Walt.; DTM 523
Asclepias tuberosa L.; DTM 463
Asclepias variegata L.; DTM 881
Asclepias verticillata L.; DTM 73
Asclepias viridiflora Raf.; DTM 556
Asclepias viridis Walt.; DTM 62
Cynanchum laeve (Michx.) Pers.; Hardy 6382
Matelea cynanchoides (Engelm.) Woods.; MM 2613
Matelea decipiens (Alexander) Woods.; RDT 51975
Matelea gonocarpos (Walt.) Shinners; RDT 36994

ASTERACEAE

Achillea millefolium L.; DTM 329
Acmella oppositifolia (Lam.) R.K. Jansen; DTM 442
Ageratina altissima (L.) King & H.E. Robins.; DTM 693
Ambrosia artemisiifolia L.; DTM 925
Ambrosia psilostachya DC.; MM 7000
Ambrosia trifida L.; DTM 2711
Antennaria parlinii Fern.; Haynes 4582
**Anthemis cotula* L.; DTM 519
Aphanostephus skirrhobasis (DC.) Trel.; DTM 1771
Arnoglossum plantagineum Raf.; DTM 407
Baccharis halimifolia L.; Hardy 6871
Berlandiera betonicifolia (Hook.) Small; DTM 1074
Berlandiera pumila (Michx.) Nutt.; DTM 997
Bidens aristosa (Michx.) Britt.; DTM 1993
Bidens bipinnata L.; Haynes 5419
Bidens discoidea (Torr. & A. Gray) Britt.; DTM 1547
Bidens frondosa L.; DTM 2024
Bidens laevis (L.) B.S.P.; DTM 1786
Boltonia diffusa Ell.; DTM 718
**Calyptocarpus vialis* Less.; DTM 1860
**Carduus nutans* L.; DTM 460
Chrysopsis pilosa Nutt.; MM 2720
**Cichorium intybus* L.; MM 223
Cirsium altissimum (L.) Spreng.; DTM 543
Cirsium carolinianum (Walt.) Fern. & Schub.; DTM 840
Cirsium engelmannii Rydb.; DTM 1966 LSU
Cirsium horridulum Michx.; DTM 555
Conoclinium coelestinum (L.) DC.; DTM 639
**Conyza bonariensis (L.) Cronq.*; Thieret 32159 LAF
Conyza canadensis (L.) Cronq.; DTM 589
Coreopsis grandiflora Hogg ex Sweet; DTM 434
Coreopsis intermedia Sherff; MM 2605
Coreopsis lanceolata L.; DTM 297
Coreopsis tinctoria Nutt.; Raymond 768 LSUS
**Crepis pulchra* L.; DTM 842
Croptilon divaricatum (Nutt.) Raf.; DTM 592
Doellingeria sericocarpoides Small; DTM 1947
Dracopis amplexicaulis (Vahl) Cass.; DTM 60
Echinacea pallida (Nutt.) Nutt.; DTM 491 (includes *E. angustifolia* DC. and *E. sanguinea* Nutt.)
Echinacea purpurea (L.) Moench; RDT 136864
Eclipta prostrata (L.) L.; DTM 247
Elephantopus carolinianus Raeusch.; DTM 8
Elephantopus nudatus Gray; RDT 155792
Elephantopus tomentosus L.; DTM 241
Erechtites hieracifolia (L.) Raf. ex DC.; DTM 1524
Erigeron annuus (L.) Pers.; DTM 1988
Erigeron philadelphicus L.; DTM 45
Erigeron pulchellus Michx.; Raymond 750 LSUS
Erigeron strigosus Muhl. ex Willd.; DTM 52
Erigeron tenuis Torr. & A. Gray; DTM 360
Eupatorium capillifolium (Lam.) Small; DTM 2007

Eupatorium compositifolium Walt.; DTM 2052
Eupatorium perfoliatum L.; DTM 206
Eupatorium rotundifolium L.; DTM 626
Eupatorium semiserratum DC.; DTM 623 (includes *E. glaucecsens* Ell.)
Eupatorium serotinum Michx.; DTM 172
Eurybia hemispherica (Alexander) Nesom; DTM 705
Euthamia leptocephala (Torr. & A. Gray) Greene; DTM 248
Evax candida (Torr. & A. Gray) A. Gray; RDT 99491 LSU
**Facelis retusa* (Lam.) Schultz-Bip.; DTM 885
Fleischmannia incarnata (Walt.) King & H.E. Robins; RDT 33060
Gaillardia aestivalis (Walt.) H. Rock; DTM 1800
Gaillardia pulchella Foug.; DTM 660
Gamochaeta antillana (Urb.) Anderb.; DTM 400
Gamochaeta argyrinea Nesom; Strout 112 LSUS
Gamochaeta pensylvanica (Willd.) Cabrera; DTM 1751
Gamochaeta purpurea (L.) Cabrera; DTM 373
Helenium amarum (Raf.) H. Rock; DTM 24
Helenium flexuosum Raf.; DTM 27
Helianthus angustifolius L.; DTM 178
Helianthus annuus L.; Barbour 490
Helianthus divaricatus L.; DTM 1894
Helianthus grosseserratus Martens; DTM 1756
Helianthus hirsutus Raf.; DTM 231
Helianthus mollis Lam.; RDT 36295
Helianthus occidentalis Riddell; Cocks s.n. NO
Helianthus petiolaris Nutt.; Cocks s.n. NO
Helianthus strumosus L.; DTM 63
Heterotheca subaxillaris (Lam.) Britt. & Rusby; MM 2777
Hieracium gronovii L.; DTM 390
Hymenopappas artemisiifolius DC.; Barbour 1193
Hymenopappas scabiosaeus L'Her.; DTM 17
**Hypochaeris glabra* L.; DTM 2830
Iva angustifolia Nutt. ex DC.; DTM 2077
Iva annua L.; DTM 2025
Krigia caespitosa (Raf.) Chambers; DTM 38
Krigia dandelion (L.) Nutt.; Raymond 731 LSUS
Krigia occidentalis Nutt.; DTM 317
Krigia virginica (L.) Willd.; DTM 1813
Lactuca canadensis L.; DTM 146
Lactuca floridana (L.) Gaertn.; DTM 651
Lactuca ludoviciana (Nutt.) Riddell; RDT 36155
**Lactuca serriola* L.; DTM 450
**Leucanthemum vulgare* Lam.; DTM 1019 (questionably naturalized)
Liatris aspera Michx.; DTM 576
Liatris elegans (Walt.) Michx.; DTM 204
Liatris pycnostachya Michx.; DTM 517
Liatris squarrosa (L.) Michx.; DTM 542
Liatris tenuis Shinners; RDT 37304
Marshallia caespitosa Nutt. ex DC.; DTM 351
Mikania scandens (L.) Willd.; DTM 209
Oligoneuron nitida (Torr. & A. Gray) Small; DTM 159
Oligoneuron rigidum (L.) Small; RDT 93593
Packera glabella (Poir.) C. Jeffrey; DTM 41
Packera obovata (Muhl. ex Willd.) W.A. Weber & A. Love; Barbour 1062
**Parthenium hysterophorus* L.; DTM 1999
Parthenium integrifolium L.; DTM 13
Pityopsis gramnifolia (Michx.) Nutt.; MM 906
Pluchea camphorata (L.) DC.; DTM 698
Pluchea foetida (L.) DC.; MM 284
Pluchea odorata (L.) Cass.; MM 277
Pseudognaphalium helleri (Britt.) A. Anderb.; RDT 41805
Pseudognaphalium obtusifolium (L.) Hilliard & Burtt; DTM 595
Pyrrhopappus carolinianus (Walt.) DC.; DTM 552
Pyrrhopappus pauciflorus (D. Don) DC.; DTM 499
Ratibida pinnata (Vent.) Barnh.; DTM 94
Rudbeckia grandiflora (D.Don) J.F. Gmel. ex DC.; DTM 914
Rudbeckia hirta L.; DTM 103
Rudbeckia maxima Nutt.; DTM 95
**Senecio vulgaris* L.; MM 5945
Silphium integrifolium Michx.; DTM 2326
Silphium laciniatum L.; MM 2054
**Silybum marianum* (L.) Gaertn.; RDT 34559
Smallanthus uvedalia (L.) Mackenzie ex Small; DTM 1088
Solidago altissima L.; DTM 627
Solidago auriculata Shuttlew. ex Blake; DTM 1916
Solidago ludoviciana (Gray) Small; MM 2889
Solidago odora Aiton; DTM 679
Solidago petiolaris Aiton; DTM 1961
Solidago radula Nutt.; Haynes 4081
Solidago rugosa P. Mill; DTM 686
Solidago ulmifolia Muhl ex Willd.; DTM 670
**Soliva sessilis* Ruiz & Pavon; DTM 1014
**Sonchus asper* (L.) Hill; DTM 424
**Sonchus oleraceus* L.; DTM 896
Symphyotrichum divaricatum (Nutt.) Nesom; Haynes 4261
Symphyotrichum drummondii (Lindl.) Nesom; DTM 2566
Symphyotrichum dumosum (L.) Nesom; MM 6957
Symphyotrichum laeve (L.)A. & D. Love; DTM 744
Symphyotrichum lanceolatum (Willd.) Nesom; DTM 2586
Symphyotrichum lateriflorum (L.) A. & D. Love; DTM 2057
Symphyotrichum ontarionis (Wieg.) Nesom; RDT 69310
Symphyotrichum oolentangiense (Riddell) Nesom; DTM 570
Symphyotrichum patens (Aiton) Nesom; MM 6200
Symphyotrichum pilosum (Willd.) Nesom; DTM 2569
Symphyotrichum praealtum (Poir.) Nesom; DTM 700
Symphyotrichum pratense (Raf.) Nesom; DTM 2080
Symphyotrichum racemosum (Ell.) Nesom; MM 6999
Symphyotrichum subulatum (Michx.) Nesom; Hardy 5297
**Taraxacum officinale* G.H. Weber ex Wiggers; DTM 283

Tetragonotheca ludoviciana (Torr. & A. Gray) A. Gray ex Hall; MM 2743
Thelesperma filifolium (Hook.) A. Gray; RDT 88997 LSU
Verbesina helianthoides Michx.; DTM 455
Verbesina virginica L.; Barbour 971
Vernonia baldwinii Torr.; MM 6798
Vernonia missurica Raf.; Raymond 773 LSUS
Vernonia texana (Gray) Small; DTM 126
Xanthium strumarium L.; DTM 1095
**Youngia japonica* (L.) DC.; DTM 3012

BALSAMINACEAE
Impatiens capensis Meerb.; DTM 1094

BERBERIDACEAE
**Nandina domestica* Thunb.; MM 6465 (questionably naturalized)
Podophyllum peltatum L.; DTM 47

BETULACEAE
Alnus serrulata (Aiton) Willd.; DTM 2228
Betula nigra L.; Hardy 8614
Carpinus caroliniana Walt.; Haynes 5316
Ostrya virginiana (P. Mill) K. Koch; Haynes 4569

BIGNONIACEAE
Bignonia capreolata L.; DTM 803
Campsis radicans (L.) Seem. ex Bureau; DTM 137
Catalpa bignonioides Walt.; Barbour 82
Catalpa speciosa (Warder) Warder ex Engelm.; Frank 134 LSUS

BORAGINACEAE
**Buglossoides arvensis* (L.) I.M. Johnston; DTM 1071
Heliotropium curassavicum L.; Thieret 21132 LAF
Heliotropium indicum L.; DTM 175
Heliotropium procumbens P.Mill; DTM 624
Lithospermum caroliniense (Walt. ex J.F. Gmel.) MacM.; MM 2534
Myosotis macrosperma Engelm.; MM 6155 (includes *Myosotis verna* Nutt.)
Onosmodium bejariense DC. ex A. DC.; Cocks s.n. NO

BRASSICACEAE
**Arabidopsis thaliana* (L.) Heynh.; RDT 70506
**Camelina microcarpa* DC.; RDT 65101 LSU
**Capsella bursa-pastoris* (L.) Medik.; DTM 256
Cardamine bulbosa (Schreb. ex Muhl.) B.S.P.; MM 6205
Cardamine concatenata (Michx.) Sw.; MM 143
**Cardamine hirsuta* L.; DTM 261
Cardamine parviflora L.; Barbour 1133
Cardamine pensylvanica Muhl. ex Willd.; DTM 1130
**Coronopus didymus* (L.) Sm.; DTM 852
**Descurainia sophia* (L.) Webb. ex Prantl; RDT 65110
Draba brachycarpa Nutt. ex Torr. & A. Gray; DTM 2587
Draba cuneifolia Nutt. ex Torr. & A. Gray; DTM 943
Lepidium densiflorum Schrad.; RDT 65049 LSU
Lepidium virginicum L.; Raymond 757 LSUS
**Rapistrum rugosum* (L.) All.; DTM 2644
**Rorippa nasturtium-aquaticum* (L.) Hayek; DTM 2204
Rorippa palustris (L.) Bess.; DTM 975
Rorippa sessiliflora (Nutt.) A.S. Hitch.; Barbour 970
Sibara virginica (L.) Rollins; Barbour 536
**Sinapis arvensis* L.; DTM 275
**Sisymbrium altissimum* L.; RDT 88306
**Sisymbrium officinale* (L.) Scop.; RDT 83089
Streptanthus hyacinthoides Hook.; MM 2656
**Thlaspi arvense* L.; Barbour 1003

BUDDLEJACEAE
Polypremum procumbens L.; DTM 154

CABOMBACEAE
Cabomba caroliniana Gray; DTM 1721

CACTACEAE
Opuntia humifusa (Raf.) Raf.; MM 239

CALLITRICHACEAE
Callitriche heterophylla Pursh; Haynes 4577
Callitriche terrestris Raf.; DTM 1125

CAMPANULACEAE
Lobelia appendiculata A. DC.; DTM 732
Lobelia cardinalis L.; DTM 2037
Lobelia puberula Michx.; DTM 225
Triodanis biflora (Ruiz & Pavon) Greene; DTM 387
Triodanis perfoliata (L.) Nieuwl.; DTM 995

CAPPARACEAE
**Cleome hassleriana* Chod.; Haynes 5938
Polanisia dodecandra (L.) DC.; RDT 64990

CAPRIFOLIACEAE
**Lonicera japonica* Thunb.; DTM 120
Lonicera sempervirens L.; DTM 402
Sambucus nigra L.; DTM 1284
Symphoriocarpus orbiculatus Moench; Raymond 865 LSUS
Triosteum angustifolium L.; DTM 2287
Viburnum nudum L.; DTM 2286
Viburnum prunifolium L.; RDT 25303
Viburnum rufidulum Raf.; MM 2823

CARYOPHYLLACEAE
Arenaria benthamii Fenzl ex Torr. & A. Gray; RDT 65108 LSU
Arenaria lanuginosa (Michx.) Rohrb.; DTM 1760
**Arenaria serpyllifolia* L.; MM 2611
Cerastium brachypodum (Engelm. ex A. Gray) B.L. Robins.; DTM 2136
**Cerastium fontanum* Baumg.; Strout 122 LSUS
**Cerastium glomeratum* Thuill.; DTM 937
Geocarpon minimum Mackenzie; MM 7284
Loeflingia squarrosa Nutt.; Reid 4855 LSU
Minuartia drummondii (Shinners) McNeill; MM 7308
Minuartia muscorum (Fassett) Rabeler; MM 7309
Paronychia drummondii Torr. & A. Gray; DTM 2448
Paronychia fastigiata (Raf.) Fern.; Correll & Correll 10096 LSU
Sagina decumbens (Ell.) Torr. & A. Gray; DTM 2723

**Saponaria officinalis* L.; MM 237
**Scleranthus annuus* L.; RDT 82790 LSU
Silene antirrhina L.; DTM 831
**Silene gallica* L.; DTM 367
**Silene noctiflora* L.; RDT 65030
Silene stellata (L.) Aiton f.; DTM 2302
**Stellaria media* (L.) Vill.; Barbour 33
**Vaccaria hispanica* (P.Mill.) Rauschert; RDT 65131 LSU

CELASTRACEAE
Evonymus americana L.; Hardy 8615

CERATOPHYLLACEAE
Ceratophyllum demersum L.; DTM 1554

CHENOPODIACEAE
**Bassia scoparia* (L.) A.J. Scott; RDT 65018
**Chenopodium album* L.; RDT 66459
**Chenopodium ambrosoides* L.; DTM 1841
Chenopodium berlandieri Moq.; RDT 66452
**Chenopodium murale* L.; DTM 931
Chenopodium pratericola Rydb.; RDT 65055
Chenopodium simplex (Torr.) Raf.; DTM 935
Chenopodium standleyanum Aellen; Overby 94 NLU
Cycloloma atriplicifolium (Spreng.) Coult.; Lewis 3663 NLU
Monolepis nuttalliana (J.A.Schultes) Greene; DTM 2196
**Salsola tragus* L.; RDT 65028 LSU

CISTACEAE
Helianthemum carolinianum (Walt.) Michx.; DTM 1616
Helianthemum georgianum Chapman; MM 2745
Helianthemum rosmarinifolium Pursh; DTM 1744
Lechea mucronata Raf.; MM 2715
Lechea tenuifolia Michx.; DTM 1785

CLUSIACEAE
Hypericum crux-andreae (L.) Crantz; DTM 586
Hypericum densiflorum Pursh; RDT 65084 LSU
Hypericum drummondii (Grev. & Hook.) Torr. & A. Gray; DTM 149
Hypericum frondosum Michx.; DTM 1257
Hypericum gentianoides (L.) B.S.P.; Allen 8539 LAF
Hypericum gymnanthum Engelm. & A. Gray; RDT 165816
Hypericum hypericoides (L.) Crantz; DTM 166
Hypericum mutilum L.; Haynes 5317
Hypericum nudiflorum Michx. ex Willd.; Raymond 1291 LSUS
Hypericum prolificum L.; RDT 42445 LSU
Hypericum pseudomaculatum Bush; DTM 453
Hypericum punctatum Lam.; DTM 1066
Triadenum walteri (J.G. Gmel.) Gleason; RDT 36265

CONVOLVULACEAE
**Convolvulus arvensis* L.; DTM 163
Dichondra caroliniensis Michx.; DTM 308
Evolvulus sericeus Sw.; MM 3355 LSU
Ipomoea cordatotriloba Dennst.; DTM 696
Ipomoea hederacea Jacq.; DTM 1920
Ipomoea lacunosa L.; DTM 667
Ipomoea panderata (L.) G.F.W. Mey.; DTM 1805
Ipomoea purpurea (L.) Roth; MM 125
Ipomoea quamoclit L.; RDT 42043
**Ipomoea wrightii* Gray; DTM 2693
Jacquemontia tamnifolia (L.) Griseb.; DTM 640
Stylisma humistrata (Walt.) Chapman; RDT 92409
Stylisma pickeringii (Torr. ex M.A. Curtis) A. Gray; MM 2677

CORNACEAE
Cornus drummondii C.A. Mey.; Hardy 8607
Cornus florida L.; Graham 571 LSUS
Cornus foemina P. Mill.; RDT 167069
Nyssa aquatica L.; RDT 37260
Nyssa sylvatica Marsh.; DTM 1638 (includes *N. biflora* T. Walter)

CRASSULACEAE
Crassula aquatica (L.) Schoenl.; RDT 34511
Penthorum sedoides L.; Raymond 683 LSUS
Sedum nuttallianum Raf.; RDT 83128 NLU

CUCURBITACEAE
Cayaponia quinqueloba (Raf.) Shinners; RDT 25353 LSU
Melothria pendula L.; DTM 233

CUSCUTACEAE
Cuscuta compacta Juss. ex Choisy; DTM 1934
Cuscuta gronovii Willd. ex. J.A. Schultes; MM 6961
Cuscuta indecora Choisy; MM 6807
Cuscuta pentagona Engelm.; DTM 1788

DROSERACEAE
Drosera brevifolia Pursh; DTM 832

EBENACEAE
Diospyros virginiana L.; DTM 1176

ELAEAGNACEAE
**Elaeagnus pungens* Thunb.; DTM 2054 (questionably naturalized)

ERICACEAE
Lyonia mariana (L.) D. Don; RDT 33683
Rhododendron canescens (Michx.) Sweet; RDT 33665
Rhododendron oblongifolium (Small) Mallais; RDT 88707
Rhododendron viscosum (L.) Torr.; DTM 2278
Vaccinium arboreum Marsh.; DTM 1637
Vaccinium corymbosum L.; Haynes 4628 (includes *V. elliottii* Chapman, *V. fuscatum* Aiton, and *V. virgatum* Aiton
Vaccinium stamineum L.; DTM 1155

EUPHORBIACEAE
Acalypha gracilens Gray; DTM 653
Acalypha monococca (Engelm. & A. Gray) L. Mill & Gandhi; RDT 66478 LSU
Acalypha ostryifolia Riddell; DTM 1392
Acalypha rhomboidea Raf.; DTM 704
Acalypha setosa A. Rich.; DTM 1092

Acalypha virginica L.; DTM 1371
Chamaesyce cordifolia (Ell.) Small; DTM 1940
Chamaesyce humistrata (Engelm.) Small; RDT 36205
Chamaesyce maculata (L.) Small; DTM 1821 LSU
Chamaesyce nutans (Lag.) Small; Haynes 4223
Chamaesyce prostrata (Aiton) Small; DTM 1830
Chamaesyce serpens (Kunth) Small; RDT 32893
Cnidoscolus texanus (Muell.-Arg.) Small; Haynes 5414
Croton argyranthemus Michx.; RDT 81395 LSU
Croton capitatus Michx.; DTM 119
Croton glandulosus L.; DTM 188
Croton michauxii G.L. Webster; MM 2772
Croton monanthogynus Michx.; DTM 170.
Croton willdenowii G.L Webster; DTM 532
Euphorbia corollata L.; DTM 71
Euphorbia dentata Michx.; MM 311
**Euphorbia helioscopia* L.; DTM 800
Euphorbia heteropylla L.; RDT 166974
Euphorbia spathulata Lam.; DTM 2272
Euphorbia tetraspora Engelm.; Moore s.n. LSU
Phyllanthus caroliniensis Walt.; MM 6981
**Phyllanthus urinaria* L.; RDT 166975
**Ricinus communis* L.; Thieret 21037 LAF (questionably naturalized)
Stillingia sylvatica Garden ex L.; DTM 1719
Tragia betonicifolia Nutt.; RDT 45419
Tragia cordata Michx.; RDT 36187
Tragia urticifolia Michx.; DTM 1345
**Triadica sebiferum* (L.) Small; DTM 1757

FABACEAE

Acacia angustissima (P. Mill.) Kuntze; DTM 74
**Albizia julibrissin* Durazz.; DTM 1079
Amorpha fruticosa L.; MM 6793
Amorpha paniculata Torr. & A. Gray; MM 255
Amphicarpaea bracteata (L.) Fern.; DTM 650
Apios americana Medik.; DTM 203
Astragalus canadensis L.; DTM 3052
Astragalus distortus Torr. & A. Gray; DTM 260
Astragalus leptocarpus Torr. & A. Gray; MM 2548
Astragalus soxmaniorum Lundell; DTM 1806
Baptisia alba (L.) Vent.; DTM 867
Baptisia bracteata Muhl. ex Ell.; MM 176
Baptisia nuttalliana Small; DTM 372
Baptisia sphaerocarpa Nutt.; MM 192
Centrosema virginianum (L.) Benth.; DTM 169
Cercis canadensis L.; Barbour 538
Chamaecrista fasciculata (Michx.) Greene; DTM 86
Chamaecrista nictitans (L.) Moench; DTM 215
Clitoria mariana L.; DTM 123
Crotalaria sagittalis L.; DTM 1287
**Crotalaria spectabilis* Roth; Thieret 21019 LAF
Dalea candida Michx. ex Willd.; DTM 124
Dalea phleoides (Torr. & A. Gray) Shinners; MM 2657
Dalea purpurea Vent.; DTM 534
Dalea villosa (Nutt.) Spreng.; DTM 1797
Desmanthus illinoensis (Michx.) MacM. ex B.L. Robins. & Fern.; DTM 1969
Desmodium canescens (L.) DC.; DTM 1973
Desmodium ciliare (Muhl. ex Willd.) DC.; DTM 211
Desmodium glabellum (Michx.) DC.; RDT 37293
Desmodium laevigatum (Nutt.) DC.; RDT 136869
Desmodium nudiflorum (L.) DC.; Overby 292 NLU
Desmodium nuttallii (Schindl.) Schub.; Raymond 2069 LSUS
Desmodium paniculatum (L.) DC.; Raymond 782 LSUS
Desmodium sessilifolium (Torr.) Torr. & A. Gray; DTM 1084
Desmodium viridiflorum (L.) DC.; RDT 37297
Dioclea multiflora (Torr. & A. Gray) C. Mohr; RDT 37291
Erythrina herbacea L.; DTM 439
Galactia volubilis (L.) Britt.; DTM 591
Gleditsia aquatica Marsh.; Reid 4636 NLU
Gleditsia triacanthos L.; Hardy 8612
Glottidium vesicarium (Jacq.) Harper; Haynes 5328
**Kummerowia striata* (Thunb.) Schindl.; DTM 1505
**Lathyrus hirsutus* L.; DTM 371
Lathyrus pusillus Ell.; DTM 795
Lathyrus venosus Muhl. ex Willd.; DTM 2199
**Lespedeza cuneata* (Dum.-Cours.) G. Don; RDT 36216
Lespedeza hirta (L.) Hornem.; DTM 678
Lespedeza procumbens Michx.; DTM 733
Lespedeza repens (L.) W. Bart.; DTM 155
Lespedeza stuevei Nutt.; MM 2812
Lespedeza violacea (L.) Pers.; RDT 152260
Lespedeza virginica (L.) Britt.; DTM 14
Lotus unifoliolatus (Hook.) Benth.; RDT 66462 LSU
Lupinus texensis Hook.; Newsom s.n. LSUS
**Medicago arabica* (L.) Huds.; DTM 362
**Medicago lupulina* L.; DTM 107
**Medicago minima* (L.) L.; RDT 70519
**Medicago polymorpha* L.; Barbour 530
**Medicago sativa* L.; DTM 110
**Melilotus albus* Medik.; DTM 147
**Melilotus indicus* (L.) All.; DTM 331
**Melilotus officinalis* (L.) Lam.; DTM 410
Mimosa nuttallii (DC.) B.L. Turner; DTM 164
Mimosa strigillosa Torr. & A. Gray; DTM 19
Neptunia lutea (Leavenworth) Benth.; DTM 50
Neptunia pubescens Benth.; Lasseigne 1002 LAF
Orbexilum pedunculatum (P. Mill.) Rydb.; DTM 385
Orbexilum simplex (Nutt. ex Torr. & A. Gray) Rydb.; DTM 1119
Parkinsonia aculeata L.; DTM 756
Pediomelum digitatum (Nutt. ex Torr. & A. Gray) Isely; MM 235
Pediomelum hypogaeum (Nutt. ex Torr. & A. Gray) Rydb.; MM 2549
Prosopis glandulosa Torr.; Cocks s.n. NO
**Pueraria montana* (Lour.) Merr.; Hardy 8896
Rhynchosia latifolia Nutt. ex Torr. & A. Gray; DTM 520
Rhynchosia minima (L.) DC.; MM 6991
Rhynchosia reniformis DC.; DTM 129

Rhynchosia tomentosa (L.) Hook. & Arn.; RDT 36931
Robinia hispida L.; MM 194
Robinia pseudoacacia L.; Haynes 5699
Senna marilandica (L.) Link; DTM 196
Senna obtusifolia (L.) Irwin & Barneby; DTM 1575
Sesbania drummondii (Rydb.) Cory; DTM 202
Sesbania herbacea (P. Mill.) McVaugh; DTM 1476
**Sesbania punicea* (Cav.) Benth.; DTM 1215
Sophora affinis Torr. & A. Gray; Cocks s.n. NO
Strophostyles helvula (L.) Ell.; DTM 564
Strophostyles leiosperma (Torr. & A. Gray) Piper; DTM 544
Strophostyles umbellata (Muhl. ex Willd.) Britt.; Raymond 779 LSUS
Stylosanthes biflora (L.) B.S.P.; MM 2713
Tephrosia onobrychoides Nutt.; DTM 1904
Tephrosia virginiana (L.) Pers.; DTM 462
**Trifolium arvense* L.; RDT 80865
**Trifolium campestre* Schreb.; DTM 151
Trifolium carolinianum Michx.; DTM 2639
**Trifolium dubium* Sibthrop; DTM 289
**Trifolium incarnatum* L.; DTM 334
**Trifolium lappaceum* L.; DTM 2641
**Trifolium pratense* L.; MM 6466
Trifolium reflexum L.; DTM 2638
**Trifolium repens* L.; DTM 136
**Trifolium resupinatum* L.; DTM 313
**Trifolium vesiculosum* Savi; DTM 125
Vicia caroliniana Walt.; DTM 2137
Vicia ludoviciana Nutt.; DTM 1160
**Vicia lutea* L.; RDT 12/204
Vicia minutiflora F.G. Dietr.; MM 152
**Vicia sativa* L.; DTM 358
**Vicia tetrasperma* (L.) Schreb.; RDT 88360 LSU
**Vicia villosa* Roth; DTM 394
Wisteria frutescens (L.) Poir.; Haynes 5356
**Wisteria sinensis* (Sims) DC.; DTM 1131
Zornia bracteata J.F. Gmel.; MM 2844

FAGACEAE

Castanea pumila (L.) P. Mill.; DTM 1202
Fagus grandifolia Ehrh.; *Manning* 208 *LTU*
Quercus alba L.; Barbour 567
Quercus arkansana Sarg.; MM 2872
Quercus falcata Michx.; Haynes 4094
Quercus hemispherica Bart. ex Willd.; RDT 32931
Quercus incana Bartr.; MM 2581
Quercus laurifolia Michx.; RDT 37236
Quercus lyrata Walt.; RDT 42015
Quercus macrocarpa Michx.; Thieret 22660 LAF
Quercus margarettiae Ashe ex Small; RDT 167037
Quercus marilandica Muencnh.; Raymond 1321 LSUS
Quercus michauxii Nutt.; DTM 2152
Quercus muhlenbergii Engelm.; RDT 36212
Quercus nigra L.; MM 5972
Quercus phellos L.; Raymond 1292 LSUS
Quercus rubra L.; Middlebrooks 206 NLU
Quercus shumardii Buckl.; Hardy 8609
Quercus stellata Wangenh.; MM 5016 (includes *Quercus similis* Ashe)
Quercus velutina Lam.; Raymond 145 NLU
Quercus virginiana P. Mill.; Rowe 105 LSUS

FUMARIACEAE

Corydalis flavula (Raf.) DC.; RDT 88228
Corydalis micrantha (Engelm. ex A. Gray) A. Gray; MM 135

GENTIANACEAE

Centaurium muehlenbergii (Griseb.) W. Wright ex Piper; MM 6435.
Sabatia angularis (L.) Pursh; DTM 145
Sabatia campestris Nutt.; DTM 72

GERANIACEAE

Geranium carolinianum L.; DTM 301
**Geranium dissectum* L.; DTM 990

GROSSULARIACEAE

Itea virginica L.; DTM 1196
Ribes curvatum Small; DTM 2129

HALORAGACEAE

**Myriophyllum aquaticum* (Vell.) Verdc.; Barbour 454
Myriophyllum heterophyllum Michx.; Barbour 908
**Myriophyllum spicatum* L.; Barbour 450
Proserpinaca palustris L.; MM 205

HAMAMELIDACEAE

Hamamelis virginiana L.; *Manning* 176 *LTU*
Liquidambar styraciflua L.; DTM 1071

HIPPOCASTANACEAE

Aesculus pavia L.; Graham 446 LSUS

HYDROPHYLLACEAE

Hydrolea ovata Nutt. ex Choisy; DTM 12
Hydrolea uniflora Raf.; DTM 11
Phacelia glabra Nutt.; DTM 335
Phacelia strictiflora (Engelm. & A. Gray) A. Gray; MM 2544

JUGLANDACEAE

Carya alba (L.) Nutt. ex Ell.; Raymond 1294 LSUS
Carya aquatica (Michx. f.) Nutt.; Barbour 909
Carya cordiformis (Wangenh.) K. Koch; Raymond 1302 LSUS
Carya glabra (P. Mill.) Sweet; RDT 170092
Carya illinoiensis (Wangenh.) K. Koch; MM 6470
Carya myristiciformis (Michx. f.) Nutt.; Graham 503 LSUS
Carya ovata (P. Mill.) K. Koch; MM 244
Carya texana Buckl.; Hardy 8611
Juglans nigra L.; Raymond 1679 NLU

LAMIACEAE

**Ajuga reptans* L.; MM 202
**Glechoma hederacea* L.; RDT 43545
Hedeoma hispida Pursh; DTM 873
**Lamium amplexicaule* L.; DTM 53
**Lamium purpureum* L.; DTM 2095
Lycopus americanus Muhl. ex W. Bart.; DTM 161

Lycopus rubellus Moench; DTM 682
Lycopus virginicus L.; RDT 37009
**Mentha spicata* L.; DTM 1839
Monarda citriodora Cerv. ex Lag.; RDT 45372
Monarda clinopodioides Gray; DTM 1753
Monarda fistulosa L.; DTM 93
Monarda punctata L.; DTM 15
**Perilla frutescens* (L.) Britt.; MM 270
Physostegia angustifolia Fern.; MM 222
Physostegia digitalis Small; DTM 527
Physostegia intermedia (Nutt.) Engelm. & A. Gray; DTM 2305
Prunella vulgaris L.; DTM 380
Pycnanthemum albescens Torr. & A. Gray; DTM 194
Pycnanthemum muticum (Michx.) Pers.; RDT 167061
Pycnanthemum tenuifolium Schrad.; DTM 54
Salvia azurea Michx. ex Lam.; DTM 214
Salvia lyrata L.; DTM 35
Scutellaria cardiophylla Engelm. & A. Gray; MM 2723
Scutellaria integrifolia L.; DTM 430
Scutellaria ovata Hill; DTM 1815
Scutellaria parvula Michx.; DTM 323
Stachys crenata Raf.; DTM 325
Stachys floridana Shuttlw. ex Benth.; MM 214
Stachys tenuifolia Willd.; DTM 1401
Teucrium canadense L.; DTM 235
Trichostema dichotomum L.; DTM 653

LAURACEAE
Lindera benzoin (L.) Blume; Hardy 8617
Sassafras albidum (Nutt.) Nees; DTM 1068

LENTIBULARIACEAE
Uticularia gibba L.; Barbour 446
Uticularia inflata Walt.; DTM 2183
Uticularia macrorhiza LeConte; Barbour 464

LINACEAE
Linum medium (Planch.) Britt.; DTM 522
Linum striatum Walt.; RDT 170116

LOGANIACEAE
Gelsemium sempervirens (L.) Aiton f.; DTM 270
Mitreola petiolata (J.F. Gmel.) Torr. & A. Gray; DTM 201
Spigelia marilandica (L.) L.; MM 210

LYTHRACEAE
Ammannia auriculata Willd.; DTM 1817
Ammannia coccinea Rottb.; MM 289
Decodon verticillatus (L.) Ell.; Lynch 2663 LSUS
Lythrum alatum Pursh ; MM 6783
Rotala ramosior (L.) Koehne; Haynes 5336

MAGNOLIACEAE
Magnolia grandiflora L.; Burns 238 LSUS
Magnolia virginiana L.; Barbour 1191

MALVACEAE
**Abutilon theophrasti* Medik.; RDT 119031
Callirhoe alcaeoides (Michx.) A. Gray; DTM 1049
Callirhoe digitata Nutt.; RDT 88370
Callirhoe involucrata (Torr. & A. Gray) A. Gray; Newsom s.n. LSU
Callirhoe papaver (Cav.) A. Gray; MM 257
Hibiscus laevis All.; DTM 92
Hibiscus moscheutos L.; DTM 168
**Hibiscus syriacus* L.; Gamblin s.n. LTU (localized and persisting)
Malvaviscus arboreus Dill. ex Cav.; MM 123
Modiola caroliniana (L.) G. Don; DTM 379
Sida rhombifolia L.; DTM 186
Sida spinosa L.; DTM 521

MELASTOMATACEAE
Rhexia mariana L.; DTM 243

MELIACEAE
**Melia azedarach* L.; MM 6183

MENISPERMACEAE
Cocculus carolinus (L.) DC.; Barbour 473

MOLLUGINACEAE
Mollugo verticillata L.; DTM 1373

MONOTROPACEAE
Monotropa hypopithys L.; Thieret 24524 LAF
Monotropa uniflora L.; MM 281

MORACEAE
**Broussonetia papyrifera* (L.) L'Her. ex Vent.; DTM 1145
Maclura pomifera (Raf.) Schneid.; Barbour 570
**Morus alba* L.; DTM 1324
Morus rubra L.; Haynes 5764

MYRICACEAE
Morella caroliniensis (P. Mill) Small; RDT 33652
Morella cerifera (L.) Small; Haynes 4507

NELUMBONACEAE
Nelumbo lutea Willd.; Barbour 467

NYCTAGINACEAE
Boerhaavia diffusa L.; DTM 2573
Boerhaavia erecta L.; RDT 65066 LSU
Mirabilis albida (Walt.) Heimerl; MM 2610

NYMPHAEACEAE
Nuphar advena (Aiton) W.T. Aiton; MM 208
Nymphaea odorata Aiton; DTM 918

OLEACEAE
Chionanthus virginicus L.; Raymond 1307 LSUS
Forestiera acuminata (Michx.) Poir.; Barbour 1004
Forestiera ligustrina (Michx.) Poir.; Raymond s.n. LSUS
Fraxinus americana L.; Hardy 8613
Fraxinus caroliniana P. Mill.; MM 252
Fraxinus pennsylvanica Marsh.; MM 6682
**Ligustrum japonicum* Thunb.; DTM 1173
**Ligustrum lucidum* Aiton f.; RDT 32907
**Ligustrum sinense* Lour.; DTM 1171

ONAGRACEAE

Gaura longiflora Spach; DTM 221
Gaura mollis James; DTM 104
Gaura sinuata Nutt. ex Ser.; DTM 1790
Ludwigia alternifolia L.; DTM 115
Ludwigia decurrens Walt.; DTM 617
Ludwigia glandulosa Walt.; DTM 1400
Ludwigia hirtella Raf.; DTM 1301
Ludwigia leptocarpa (Nutt.) Hara; DTM 226
Ludwigia linearis Walt.; DTM 622
Ludwigia palustris (L.) Ell.; Haynes 4090
Ludwigia peploides (Kunth) Raven; Haynes 4087
Ludwigia repens J.R. Forst.; MM 6633
Oenothera biennis L.; MM 2685
Oenothera heterophylla Spach; Thieret 31220 LAF
Oenothera laciniata Hill; DTM 79
Oenothera linifolia Nutt.; DTM 311
Oenothera spachiana Torr. & A. Gray; DTM 989
Oenothera speciosa Nutt.; DTM 122

OXALIDACEAE

Oxalis corniculata L.; MM 5947
**Oxalis debilis* Kunth; MM 321
Oxalis dillenii Jacq.; MM 171
**Oxalis rubra* St.-Hil.; DTM 492
Oxalis violacea L.; DTM 417

PAPAVERACEAE

**Papaver rhoeas* L.; Barbour 560 (questionably naturalized)

PASSIFLORACEAE

Passiflora incarnata L.; DTM 133
Passiflora lutea L.; DTM 96

PEDALIACEAE

Proboscidea louisianica (P. Mill.) Thellung; Hall s.n. LSUS

PHRYMACEAE

Phryma leptostachya L.; DTM 1290

PHYTOLACCACEAE

Phytolacca americana L.; DTM 61
Rivinia humilis L.; DTM 1490

PLANTAGINACEAE

Plantago aristata Michx.; DTM 1025
Plantago heterophylla Nutt.; MM 6023
Plantago hookeriana Fisch. & C.A. Mey.; MM 2580
**Plantago lanceolata* L.; DTM 897
Plantago patagonica Jacq.; RDT 88695
Plantago pusilla Nutt.; MM 7301
Plantago rhodosperma Dcne.; RDT 65015
Plantago virginica L.; DTM 1026
Plantago wrightiana Dcne.; DTM 913

PLATANACEAE

Platanus occidentalis L.; Haynes 4634

POLEMONIACEAE

Phlox divaricata L.; Lawrence 17 LTU
Phlox drummondii Hook.; MM 197
Phlox pilosa L.; Raymond 1200 LSUS

POLYGALACEAE

Polygala mariana P. Mill.; RDT 170119
Polygala polygama Walt.; MM 2629
Polygala sanguinea L.; DTM 461
Polygala verticillata L.; RDT 36193

POLYGONACEAE

Brunnichia ovata (Walt.) Shinners; DTM 171
Eriogonum longifolium Nutt.; MM 2323
Eriogonum multiflorum Benth.; MM 2870
Polygonella americana (Fisch. & C.A. Mey.) Small; MM 2816
**Polygonum aviculare* L.; DTM 1336
**Polygonum caespitosum* Blume; RDT 170115
**Polygonum convolvulus* L.; RDT 66461 LSU
Polygonum densiflorum Meisn.; DTM 608
Polygonum erectum L.; RDT 32876
Polygonum hydropiperoides Michx.; DTM 113
**Polygonum lapathifolium* L.; DTM 601
Polygonum pensylvanicum L.; DTM 213
**Polygonum persicaria* L.; Haynes 4222
Polygonum punctatum Ell.; Haynes 4224
Polygonum ramosissimum Michx.; DTM 643
Polygonum scandens L.; MM 292
Polygonum setaceum Baldw.; DTM 239
Polygonum virginianum L.; Raymond 775 LSUS
Rumex altissimus Wood; DTM 1192
**Rumex crispus* L.; DTM 817
Rumex hastatulus Baldw.; DTM 798
**Rumex pulcher* L.; DTM 865
Rumex verticillatus L.; DTM 907

PORTULACACEAE

Claytonia virginica L.; DTM 116
Portulaca oleracea L.; DTM 692
Talinum parviflorum Nutt.; MM 3354
Talinum rugospermum Holz.; MM 2757

PRIMULACEAE

**Anagallis arvensis* L.; Lynch 3861 LSUS
Anagallis minima (L.) Krause; DTM 1135
Dodecatheon meadia L.; DTM 314
Lysimachia lanceolata Walt.; Graham 565 LSUS
Samolus valerandi L.; DTM 374

RANUNCULACEAE

Anemone berlandieri Pritz.; DTM 2590
Anemone caroliniana Walt.; DTM 264
Clematis crispa L.; MM 267
Clematis reticulata Walt.; MM 2680
**Clematis terniflora* DC.; MM 122
Clematis virginiana L.; MM 269
Delphinium carolinianum Walt.; MM 2774
Myosurus minimus L.; Barbour 556
Ranunculus abortivus L.; DTM 953
Ranunculus fascicularis Muhl. ex Bigelow; DTM 773
Ranunculus laxicaulis (Torr. & A. Gray) Darby; DTM 292

**Ranunculus marginatus* d'Urv.; DTM 980
**Ranunculus muricatus* L.; DTM 409
**Ranunculus parviflorus* L.; DTM 878
Ranunculus pusillus Poir.; DTM 775
Ranunculus recurvatus Poir.; DTM 1047
**Ranunculus sardous* Crantz; DTM 1048
Ranunculus sceleratus L.; DTM 2019
**Ranunculus trilobus* Desf.; DTM 902
Thalictrum dasycarpum Fisch. & Ave-Lall.; DTM 901

RHAMNACEAE

Berchemia scandens (Hill) K. Koch; DTM 1781
Ceanothus americanus L.; MM 2370
Ceanothus herbaceus Raf.; RDT 93612
Frangula caroliniana (Walt.) A.Gray; Hardy 8646
**Ziziphus zizyphus* (L.) Karst.; RDT 33078

ROSACEAE

Agrimonia microcarpa Wallr.; Haynes 5337
Agrimonia rostellata Wallr.; Haynes 5315
Amelanchier arborea (Michx.f.) Fernald; *Manning* 485 *LTU*
**Aphanes microcarpa* (Boiss. & Reut.) Rothm.; RDT 82794
Aronia arbutifolia (L.) Ell.; RDT 33632
Crataegus berberifolia Torr.& A.Gray; Graham 460 LSUS
Crataegus brachyacantha Sarg. & Engelm.; Rowe 85 LSUS
Crataegus crus-galli L.; RDT 165825
Crataegus engelmannii Sarg.; DTM 1966 LSU
Crataegus marshallii Egglest.; Haynes 4623
Crataegus opaca Hook. & Arn.; Haynes 4627
Crataegus spathulata Michx.; Haynes 4095
Crataegus uniflora Muenchh.; MM 2578
Crataegus viridis L.; Barbour 1164
**Duchesnea indica* (Andr.) Focke; DTM 4
Geum canadense Jacq.; DTM 387
Malus angustifolia (Aiton) Michx.; RDT 88278
Porteranthus stipulatus (Muhl.ex Willd.) Britt.; DTM 1030
**Potentilla recta* L.; MM 2620
Potentiilla simplex Michx.; DTM 48
Prunus americana Marsh.; RDT 96045
Prunus angustifolia Marsh.; MM 2538
Prunus caroliniana (P.Mill.) Aiton; DTM 1121
Prunus gracilis Engelm. & A. Gray; MM 2539
Prunus mexicana S.Wats.; Raymond 69 LSUS
Prunus serotina Ehrh.; Barbour 47
Prunus umbellata Ell.; DTM 1603
**Pyrus calleryana* Dcne.; MM 5976
**Rosa bracteata* J.C.Wendl.; Barbour 462 (questionably naturalized)
Rosa carolina L.; MM 201
**Rosa laevigata* Michx.; Barkley 103 LSU (questionably naturalized)
**Rosa multiflora* Thunb. ex Murr.; Lynch 2273 LSUS (questionably naturalized)
Rosa setigera Michx.; MM s.n.
Rubus argutus Link.; Raymond 2006 LSUS
Rubus trivialis Michx.; Graham 444 LSUS

RUBIACEAE

Cephalanthus occidentalis L.; DTM 1296
Diodia teres Walt.; DTM 156
Diodia virginiana L.; DTM 83
Galium aparine L.; DTM 288
Galium circaezans Michx.; DTM 922
Galium obtusum Bigelow; DTM 994
**Galium parisiense* L.; RDT 88323
Galium pilosum Aiton; DTM 915
Galium tinctorium (L.) Scop.; DTM 355
Galium triflorum Michx.; RDT 43947
Galium uniflorum Michx.; RDT 33621
Hedyotis nigricans (Lam.) Fosberg; MM 227
Houstonia micrantha (Skinner) Terrell; DTM 1979
Houstonia pusilla Schoepf; Raymond 741 LSUS
Houstonia rosea (Raf.) Terrell; DTM 255
Mitchella repens L.; DTM 378
Oldenlandia boscii (DC.) Chapman; DTM 2996
Oldenlandia uniflora L.; RDT 33607
Richardia scabra L.; DTM 1919
**Sherardia arvensis* L.; DTM 269
Spermacoce glabra Michx.; DTM 111

RUTACEAE

**Poncirus trifoliata* (L.) Raf.; MM 160
Ptelea trifoliata L.; RDT 36987
Zanthoxylum clava-herculis L.; Raymond 1319 LSUS

SALICACEAE

**Populus alba* L.; DTM 2230
Populus deltoides Bartr.ex Marsh.; Haynes 4633
Salix exigua Nutt.; Haynes 4157
Salix humilis Marsh.; RDT 88359 *LSU*
Salix nigra Marsh.; Haynes 5700

SAPINDACEAE

Cardiospermum halicacabum L.; Haynes 5292
Sapindus saponaria L.; RDT 88240

SAPOTACEAE

Sideroxylon lanuginosa Michx.; MM 2828
Sideroxylon lycioides L.; RDT 33011

SAURURACEAE

Saururus cernuus L.; DTM 30

SAXIFRAGACEAE

Heuchera americana L.; Haynes 5763
Lepuropetalon spathulatum Ell.; RDT 34504

SCROPHULARIACEAE

Agalinis caddoensis Pennell; Pennell 5658 PH
Agalinis fasciculata (Ell.) Raf.; DTM 755
Agalinis gattingeri (Small) Small; DTM 541
Agalinis heterophylla (Nutt.) Small ex Britt.; DTM 736
Agalinis homalantha Pennell; DTM 748
Agalinis purpurea (L.) Pennell; DTM 2570

Agalinis tenuifolia (Vahl) Raf.; DTM 2582
Agalinis viridis (Small) Pennell; DTM 31
Aureolaria grandiflora (Benth.) Pennell; DTM 605
Aureolaria pectinata (Nutt.) Pennell; Cocks s.n. NO
Bacopa rotundifolia (Michx.) Wettst.; DTM 1592
Buchnera americana L.; DTM 21
Castilleja indivisa Engelm.; Barbour 62
**Chaenorhinum minus* (L.) Lange; RDT 65115 *LSU*
Collinsia violacea Nutt.; Maynard 151 LTU
Dasistoma macrophylla (Nutt.) Raf.; Palmer 10611 MO
Gratiola flava Leavenworth; MM 7285
Gratiola neglecta Torr.; DTM 398
Gratiola pilosa Michx.; RDT 33636
Gratiola virginiana L.; DTM 1127
Leucospora multifida (Michx.) Nutt.; DTM 1103
Lindernia crustacea (L.) F. Muell.; RDT 41803
Lindernia dubia (L.) Pennell; DTM 165
**Mazus pumilus* (Burm. f.) Steenis; DTM 964
Mecardonia acuminata (Walt.) Small; DTM 216
Mimulus alatus Aiton; DTM 603
Nuttallanthus canadensis (L.) D.A. Sutton; DTM 263
Nuttallanthus texanus (Scheele) D.A. Sutton; DTM 381
**Parentucellia viscosa* (L.) Caruel; MM 2627
Pedicularis canadensis L.; DTM 37
Penstemon digitalis Nutt. ex Sims; Graham 554 LSUS
Penstemon laxiflorus Pennell; DTM 811
Penstemon murrayanus Hook.; MM 2317
Penstemon tenuis Small.; DTM 557
Penstemon tubaeflorus Nutt.; DTM 81
Scrophularia marilandica L.; RDT 88232
**Verbascum blatteria* L.; Hardy 6535
**Verbascum thapsus* L.; DTM 200
**Veronica arvensis* L.; DTM 262
**Veronica hederifolia* L.; Burns 13 LSUS
Veronica peregrina L.; DTM 303
**Veronica persica* Poir.; MM 5966
**Veronica polita* Fries; DTM 273

SIMAROUBACEAE
**Ailanthus altissima* (P. Mill.) Swingle; Lewis 2185 NLU

SOLANACEAE
**Datura stramonium* L.; DTM 930
Physalis angulata L.; DTM 187
Physalis cineraesens (Dunal) A.S. Hitchc.; RDT 32855
Physalis cordata P. Mill.; RDT 32854
Physalis hederifolia Gray; RDT 89017
Physalis heterophylla Nees; MM 2619
Physalis longifolia Nutt.; MM 6667
Physalis mollis Nutt.; MM 2608
Physalis pubescens L.; DTM 1779
Physalis pumila Nutt.; RDT 140326
Solanum carolinense L.; DTM 99
Solanum dimidiatum Raf.; Petersen s.n. LSU
Solanum elaeagnifolium Cav.; DTM 108
**Solanum pseudocapsicum* L.; Raymond 2149 LSUS
Solanum ptychanthum Dunal; DTM 118
Solanum rostratum Dunal; RDT 81358

SPHENOCLEACEAE
**Sphenoclea zeylandica* Gaertn.; RDT 36943

STYRACACEAE
Styrax americanus Lam.; MM 189
Styrax grandifolius Aiton; RDT 37239

SYMPLOCACEAE
Symplocos tinctoria (L.) L'Her.; Barbour 1166

TAMARICACEAE
**Tamarix gallica* L.; DTM 1318

TILIACEAE
Tilia americana L.; DTM 1144

ULMACEAE
Celtis laevigata Willd.; Haynes 4092
Celtis tenuifolia Nutt.; RDT 37283
Planera aquatica J.F. Gmel.; Haynes 8648
Ulmus alata Michx.; Haynes 4508
Ulmus americana L.; Haynes 4574
Ulmus crassifolia Nutt.; Hardy 8610
Ulmus rubra Muhl.; Raymond 308 LSUS

URTICACEAE
Boehmeria cylindrica (L.) Sw.; DTM 224
Parietaria pensylvanica Muhl. ex Willd.; DTM 1796
Pilea pumila (L.) A. Gray; MM 2950
Urtica chamaedryoides Pursh; DTM 3

VALERIANACEAE
Valerianella radiata (L.) Dufr.; DTM 1028

VERBENACEAE
Callicarpa americana L.; DTM 1069
Glandularia bipinnatifida (Nutt.) Nutt.; RDT 99514
Glandularia canadensis (L.) Nutt.; DTM 9
**Glandularia pulchella* (Sweet) Troncoso; DTM 1355
**Lantana camara* L.; RDT 36934
Lantana urticoides Hayek; DTM 1570
Phyla lanceolata (Michx.) Greene; DTM 22
Phyla nodiflora (L.) Greene; DTM 98
**Verbena bonariensis* L.; DTM 1298
Verbena bracteata Lag. & Rodr.; RDT 65091
**Verbena brasiliensis* Vell; DTM 661
Verbena halei Small; DTM 330
**Verbena rigida* Spreng.; DTM 893
Verbena urticifolia L.; DTM 609
Verbena xutha Lehm.; DTM 440
**Vitex agnus-castus* L.; MM 226

VIOLACEAE
Viola bicolor Pursh; DTM 257
Viola lanceolata L.; DTM 2106
Viola palmata L.; DTM 772
Viola pedata L.; DTM 43
Viola primulifolia L.; DTM 2161
Viola pubescens Aiton; RDT 119113
Viola sagittata Aiton; DTM 2602

Viola sororia Willd.; DTM 788
Viola villosa Walt.; MM 141
Viola walteri House; DTM 816

VISCACEAE

Phoradendron tomentosum (DC.) Engelm. ex A. Gray; DTM 2102

VITACEAE

Ampelopsis arborea (L.) Koehne; DTM 152
Ampelopsis cordata Michx.; DTM 905
Cissus incisa Des Moul.; DTM 1784
Parthenocissus quinquefolia (L.) Planch.; MM 6208
Vitis aestivalis Michx.; DTM 912
Vitis cinerea (Engelm.) Millard; Correll & Correll 10091 DUKE
Vitis palmata Vahl; RDT 25315
Vitis riparia Michx.; DTM 1159
Vitis rotundifolia Michx.; MM 6201
Vitis vulpina L.; RDT 42042

ZYGOPHYLLACEAE

**Tribulus terrestris* L.; DTM 600

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Book Review

Douglas J. Kennet and Bruce Winterhalder. 2006. **Behavioral Ecology and the Transition to Agriculture.** (ISBN 0-520-24647-0, hbk.). University of California Press, California/Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A. (**Orders:** www.ucpress.edu/, 609-883-1759, 609-883-7413 fax). $60.00, 407 pp., 3 b/w photos, 31 line illustrations, 22 maps, 30 tables, 7" × 10".

Human behavioral ecology (as in the Foreword) focuses on how and why people have chosen, in social and cultural contexts, to exploit particular resources. From the Preface: "This volume examines "one of the most fundamental economic shifts in human history—the evolutionary transition from foraging to farming through processes of plant and animal domestication and the emergence of agriculture. The chapter authors use a variety of geographically dispersed case studies and analytical approaches, including subsistence choice optimization, central place foraging, discounting, risk minimization, and costly signaling theory Their contributions are novel in presenting regionally comprehensive case studies that address the transition to agriculture from a consistent conceptual framework informed by neo-Darwinian theory." A collection of 14 technical but readable papers.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

Book Notice

W. Shengyi, Peter H. Raven, and H. Deyuan (editorial co-chairs). 2006. **The Flora of China, Volume 22, Poaceae.** (ISBN 1-930723-50-4, hbk.). Missouri Botanical Garden Press, P.O. Box 299, Saint Louis, MO 63166-0299, U.S.A. (**Orders:** 877-271-1930, http://www.mbgpress.org) $140.00, 752 pp., 9" × 11 1/2".

"Volume 22 of the Flora of China is the 12th of a 25-volume work. It includes a single family, the Poaceae, which in China comprises 28 tribes, 226 genera, and 1795 species, among which seven genera and 809 species are endemic to China." Except for the protracted list of Asian Bambuseae genera (34), the similarity in genera between China and North America is remarkable. The Chinese grass flora also is close in size to the North American one (north of Mexico), perhaps even 20% greater in number of species. The first of two volumes of the FNA treatment was published in 2003; it will be published in early 2007. Many recent changes in concepts of grass genera are incorporated in the Chinese flora, presumably making it parallel and comparable with the FNA treatments.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

CAREX STIPATA (CYPERACEAE), *CHAMAESYCE GEYERI* (EUPHORBIACEAE), *EURYTAENIA TEXANA* (APIACEAE), *PEDIOMELUM ESCULENTUM* (FABACEAE), AND *TALINUM CALYCINUM* (PORTULACACEAE) DELETED FROM THE LOUISIANA FLORA

Barbara R. MacRoberts and Michael H. MacRoberts

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In the course of developing a vouchered checklist of the vascular flora of Caddo Parish, Louisiana (MacRoberts & MacRoberts in prep.), we discovered six species reported for Caddo Parish for which we could find vouchers neither for the Parish nor the State. We already have reported on one of these: *Agrimonia gryposepala* Wallr. (MacRoberts & MacRoberts 2005). Here we report on five others. Until vouchers are found, these species should be deleted from the Louisiana flora.

Carex stipata.—MacRoberts (1979, 1984, 1989), Thomas and Allen (1993–1998), Kartesz and Meacham (1999), NatureServe (2005), and U.S.D.A. (2005) include *Carex stipata* Muhl. ex Willd. in the Louisiana flora based on a specimen collected by D.T. MacRoberts in Caddo Parish (*MacRoberts 1349* LSUS). We examined the specimen and found it to be a misidentified *Carex vulpinoidea* Michx. (Phil Hyatt also annotated it to *C. vulpinoidea*). The reported distribution of *C. stipata* is confused. It is not reported for Louisiana, Mississippi, or Arkansas in the *Flora of North America* but it is reported for these states by Kartesz and Meacham (1999), NatureServe (2005), and U.S.D.A. (2005). Turner et al. (2003) do not report it for Texas.

Chamaesyce geyeri.—MacRoberts (1979, 1984, 1989), Thomas and Allen (1993–1998), Kartesz and Meacham (1999), NatureServe (2005), and U.S.D.A. (2005) include *Chamaesyce geyeri* (Engelm.) Small in the Louisiana flora based on several specimens collected by D.T. MacRoberts in Caddo Parish (*MacRoberts 1791, 1940* LSUS, *1951* LSU). We examined these specimens and found them to be misidentified *Chamaesyce cordifolia* (Ell.) Small. *Chamaesyce geyeri* is a central plains species that apparently does not occur nearer to Louisiana than central Texas and central Oklahoma (Turner et al. 2003, Oklahoma Vascular Plant Database 2005).

Eurytaenia texana.—Thieret (1971), MacRoberts (1979, 1984, 1989), Thomas and Allen (1993–1998), Kartesz and Meacham (1999), LSU (2005), NatureServe (2005), and U.S.D.A. (2005) include *Eurytaenia texana* Torr. & A. Gray in the Louisiana flora on the basis of many collections from Caddo, Winn, Webster, and DeSoto parishes (e.g., *Thieret 32309* LAF, *Thomas 45467, 65016, 70521, 99542, 99703* NLU, *Thompson 485* LTU, *Dixon 1342* NLU). We examined these specimens and others labeled *Eurytaenia texana* from Louisiana in BRIT, NLU, LSU, LTU, and LAF, and found all of them to be misidentified *Polytaenia*

nuttallii DC. The distribution of *Eurytaenia texana* is central Texas, the Texas coastal prairie region, and western Oklahoma (Mathias & Constance 1961, Taylor & Taylor 1989, Hatch et al. 1990, Turner et al. 2003, Oklahoma Vascular Plant Database 2005, TAMU 2005). It is, however, reported from Jefferson Co., Texas, on the Louisiana Gulf border and thus could possibly be present in the Louisiana coastal prairie region (Mathias & Constance 1961, Turner et al. 2003). A reported specimen of *Eurytaenia texana* from Arkansas housed at NLU turned out to be a misidentified *Thaspium barbinode* (Michx.) Nutt. (Eric Sundell, pers. comm.).

Pediomelum esculentum.—MacRoberts (1979, 1984, 1989), Thomas and Allen (1993–1998), Kartesz and Meacham (1999) and U.S.D.A (2005) include *Pediomclum esculentum* (Pursh) Rydb. in the Louisiana flora based on a specimen collected by D.T. MacRoberts from Caddo Parish (*MacRoberts 1170* LSUS). We examined the specimen and found it to be a misidentified *Pediomelum hypogaeum* (Nutt. ex Torr. & A. Gray) Rydb. var. *subulatum* (Bush) J. Grimes. *Pediomelum esculentum* apparently does not occur nearer to Louisiana than northern Arkansas and central Oklahoma (Oklahoma Vascular Plant Database 2005, U.S.D.A. 2005).

Talinum calycinum.—MacRoberts (1979, 1984, 1989), Thomas and Allen (1993–1998), Kartesz and Meacham (1999), NatureServe (2005) and U.S.D.A (2005) include *Talinum calycinum* Engelm. in the Louisiana flora based on specimens collected by Thomas in Caddo and Vernon parishes (*Thomas 34513, 105079* NLU). We examined all Louisiana *T. calycinum* specimens (MacRoberts & MacRoberts 1997) and found them to be misidentified *T. parviflorum* Nutt. *Talinum calycinum* apparenty does not occur nearer to Louisiana than central Texas, Oklahoma, and central Arkansas (Turner et al. 2003, Oklahoma Vascular Plant Database 2005, U.S.D.A. 2005).

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Book Notices

Yong No Lee. 2006. **New Flora of Korea** (two volume set). (ISBN 89-09-11801-6, vol. 1; ISBN 89-09-11802-4, vol. 2, hbk.). Kyo-Hak Publishing Co., Ltd., 105-67, Gongdeok-dong, Mapo-gu, Seoul, Korea. (**Orders:** 02-7075-155-156, 02-7075-160 Fax, chief@kyohak.co.kr, www.kyohak.co.kr) $345.00 (postage (surface) included to U.S.A.), 976 pp., vol. 1; 888 pp., vol. 2, abundant color photographs, 9" × 11 1/2".

So many beautiful and detailed color photos (I estimate 80+% of the species with a photo: match photo number with species number) ... but I can read the scientific names, that's all. Ferns, grasses, sedges, trees, daisies, and all the rest—all illustrated in two big volumes (boxed set). It's not cheap but what a value for botanists. From the 'flyer': 4157 taxa of native and naturalized plants of Korea; almost all plant pictures have been taken by the author; Vol. I with 976 pages, Vol. II with 888; scientific names, proper Korean names, English names, Chinese names, and Japanese names have been used; habitats, distributions, flowering seasons, and chromosome numbers have been recorded; new species and rearranged species names have been arranged in an appendix (primarily an index of new taxa and new combinations by the author in various literature from 1993 to early 2006, joined by many new combinations proposed here de novo). Since synonyms are given for very few of the scientific names, the index to scientific names functions as a checklist for the whole flora.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

David Baxter (Photographs by Laurence Parent). 2002. **Nature of the Forest: Temple-Inland's Timberlands in the Twenty-first Century.** (ISBN 009718675-0-X, hbk.). Temple-Inland Inc. No other information provided.

It's not easy to be enthusiastic about books about timber companies, published by timber companies, because so much private forest land has been turned to monoculture, the diversity of all plants reduced literally to a few species. Practices of the USDA Forest Service commonly give the same result over large portions of public land. This book obviously is intended to put the best face possible on the Temple-Inland timber company—nicely written and full of beautiful pictures. But TI is surely one of the white (whiter?) hats among the big players in timber management, as it apparently has set aside an unusual amount of land for preservation of natural communities. The book notes that "Temple maintains about a quarter of its land as natural forest;" ... some seventeen percent of its land is in SMZs [streamside management zones]—340,000 acres. Plans are to level off at eighteen to twenty percent of the company's total acreage." It also maintains a number of "special places" conserved within its holdings in east Texas, Alabama, and Georgia, and in 2006 the Native Plant Society of Texas recognized Temple-Inland with an award for its contribution to native plant habitat preservation in East Texas.

As noted in the book, "Temple-Inland is in the tree business, but the greater Temple-Inland company has expertise in real estate development. As such, Temple is positioned to develop some company land for its 'highest and best use.' Temple already owns the land, so would not be out the cost of acquisition, and might look at other types of development." The ultimate fate of TI holdings and all timber lands has recently become conspicuously unpredictable—Boise-Cascade sold all of its 2.3 million acres of forestland in 2004, and in 2005 International Paper announced the sale of its 6.8 million acres of North American timberland, including many conservation areas (see Nature Conservancy, Autumn 2006). Only a small fraction of this land has been moved into some kind of conservation status. At least commercial timber land, even with its greatly reduced species diversity, can be coaxed back into a semi-natural condition, but other kinds of development (housing or commercial) are more nearly irrevocable.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A.*

NEW VASCULAR PLANT RECORDS FOR NEW MEXICO

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ABSTRACT

Additions to the vascular flora of New Mexico are reported herein: *Achnatherum nelsonii* var. *nelsonii*, *Betula glandulosa*, *Cardamine cordifolia* var. *incana*, *Carex deweyana* var. *deweyana*, *Carex rosea*, *Cynosurus echinatus*, *Draba grayana*, *Equisetum* ×*nelsonii*, *Erigeron nivalis*, *Geum triflorum* var. *triflorum*, *Heuchera hallii*, *Juglans nigra*, *Lactuca biennis*, *Lepidium ramosissimum* var. *bourgeauanum*, *Neoparrya lithophila*, *Penstemon glaber* var. *alpinus*, *Piptatherum pungens*, *Potentilla fissa*, *Prunus persica*, *Ranunculus alismifolius* var. *montanus*, *Ranunculus repens*, *Rorippa sylvestris*, *Rudbeckia laciniata* var. *laciniata*, and *Syringa vulgaris*.

RESUMEN

Se aportan las adiciones siguientes a la flora vascular de Nuevo México: *Achnatherum nelsonii* var. *nelsonii*, *Betula glandulosa*, *Cardamine cordifolia* var. *incana*, *Carex deweyana* var. *deweyana*, *Carex rosea*, *Cynosurus echinatus*, *Draba grayana*, *Equisetum* ×*nelsonii*, *Erigeron nivalis*, *Geum triflorum* var. *triflorum*, *Heuchera hallii*, *Juglans nigra*, *Lactuca biennis*, *Lepidium ramosissimum* var. *bourgeauanum*, *Neoparrya lithophila*, *Penstemon glaber* var. *alpinus*, *Piptatherum pungens*, *Potentilla fissa*, *Prunus persica*, *Ranunculus alismifolius* var. *montanus*, *Ranunculus repens*, *Rorippa sylvestris*, *Rudbeckia laciniata* var. *laciniata*, y *Syringa vulgaris*.

Past and recent inventories on the flora of north central New Mexico have resulted in 24 native or naturalized taxa new to the state or verification of reports. Much of this work is part of an ongoing inventory of the Rocky Mountains by the students and staff of the Rocky Mountain Herbarium (http://www.rmh.uwyo.edu). Thus far more than 44 intensive, large-scale projects have been completed. More specifically, these records are the result of the following inventories: Philmont National Scout Ranch (Hartman 1973), Bandelier National Monument (Jacobs 1989), Valles Caldera National Preserve (Hartman & Nelson 2005), and the Santa Fe National Forest (Reif & Hartman 2005; Reif 2006). An additional study, Carson National Forest and adjoining Bureau of Management lands, is in its second year (Larson, Hartman, and Nelson, unpub.). All specimens are deposited at the Rocky Mountain Herbarium (RM) or at the herbarium of Bandelier National Monument (here designated BAND). Determination that a taxon is new to New Mexico is based on Allred (2005). In several instances a taxon included in this report has been attributed to New Mexico, but without documentation.

SIDA 22(2): 1225– 1233. 2006

APIACEAE

Neoparrya lithophila Mathias—The type locality for this species was attributed to New Mexico ("on rocks, Huefano [Huerfano] Mts, New Mexico, Sept., 1867, *C.C. Parry 83*") but is now considered to be from Huerfano Co., Colorado (Weber 1958, Theobald et al. 1964). Hartman (in O'Kane et al. 1988) reported it from several sites as far as 51 mi to the southwest and 70–80 mi to the west of the type locality, previously the only known site for the species. Based on this report and subsequent inventory in San Isabel and Rio Grande National Forests and vicinity, it is now documented from more than 30 localities largely along the eastern margin of the San Juan Volcanic Area. Most recently, collections (RLH) have been made in the South Piñon Hills in the extreme southern San Luis Valley, immediately to the north of the locality reported below. Thus a taxon originally attributed erroneously to New Mexico, then considered endemic to Colorado, indeed occurs in New Mexico but only by one-half mile.

Voucher specimen: **Taos Co.**: Carson National Forest and Vicinity, southern extension of Pinon Hills into New Mexico, N36.9915 W105.7935, 7900 ft elev., rocky outcrop, 29 Jul 2005, *Hartman 81599* (RM).

ASTERACEAE

Erigeron nivalis Nutt.—The following specimen was included in Allred (2005) as *E. acris* var. *asteroides* (Anderz. ex Besser) DC. due to a misidentification (Hartman 2003). In the United States, *E. nivalis* ranges from the Rocky Mountains to the West Coast excluding Arizona and Nevada. It was attributed to New Mexico by Nesom (2006) based on the *Ludwig and Smith* and the *Reif* collections cited below.

Voucher specimens: **Sandoval Co.**: Baca Land and Cattle Company, Redondo Peak, N35.87 W 106.66, 10925 ft elev., talus slope, 1–9 Jul 1975, *J. Ludwig and S. Smith 1368* (NMC); Valles Caldera National Preserve, Jemez Mountains: upper slopes on NE side of Redondo Peak, N35.8806 W106.5484, 10160–10360 ft elev., roadside along volcanic outcrop, open slopes, and forested areas, 15 Jul 2002, *Reif 2403* (NMC, RM); trip from 7 roads to "Redondito peak" and down the La Jara Creek to headquarters: 0.5–0.7 air mi ENE of 7 roads, N35.8923 W106.5536 to N35.8908 W106.5480, 9730–9970 ft elev., spruce-fir forest and adjacent felsenmeer and grown over 2-tracks, 18 Jul 2003, *Hartman 77974* (RM).

Lactuca biennis (Moench) Fernald—USDA, NRCS (2006) maps this taxon for New Mexico but without voucher data and it is not included in Allred's checklist (2005). Thus documentation is provided below.

Voucher specimens: **Colfax Co.**: Philmont Scout Ranch: Middle Fork Cimarroncito Creek, 1 mi W of Hunting Lodge, N36.4844 W105.0801, 8200 ft elev., exposed waste run along road, 7 Aug 1968, *Hartman 2626* (RM). **Sandoval Co.**: Rito de los Frijoles, N35.7793 W106.2719, Aug 1910, *Robbins 8210* (RM). Bandelier National Monument: Frijoles Canyon, ca. 2 mi below Upper Crossing, N35.8044 W106.3301, 6500 ft elev., moist canyon bottom along stream, 24 Jul 1988, *B. Jacobs and E. Jacobs 4353* (BAND); 20 Jul 1941, *Clark 9935* (BAND). **San Miguel Co.**: Beulah, N35.8050 W105.4407, 8000 ft elev., Aug 1902, *Cockerell 11* (RM). Santa Fe National Forest and Vicinity: Sangre de Cristo Mountains: Maestas Creek on NM hwy 391, 4.5 air mi WNW of Rociada, N35.8568 W105.4897, 8500–8680 ft elev., riparian and moist banks of creek, 15 Aug 2002, *Reif 4080* (RM); Pecos Wilderness Area, Holy Ghost Creek, 3 air mi NW of Terrero, N35.7856 W105.7048, 8100–8360 ft elev., pockets of meadow in canyon bottom, 28 Jul 2002, *Reif 2768* (RM); Dalton Canyon on NM hwy 123 branching W of the Pecos River, 6 air mi NNW of Pecos, N35.6712 W105.7412, 7760 ft elev., wet to dry meadow and riparian with canyon constricting to the W, 6 Aug 2002, *Reif 3392* (RM).

Rudbeckia laciniata L. var. **laciniata**—Variety *ampla* (A. Nelson) Cronq. is not distinguished from the typical variety in Allred (2005). The former is the common variety throughout the Rocky Mountains with var. *laciniata* entering the region from the Great Plains. USDA, NRCS (2006) indicates its occurrence in New Mexico but without documentation. Thus

var. *laciniata* is vouchered below for the state and the reader is referred to Urbatsch and Cox (2006) for the discrimination of the two taxa.

Voucher specimens: **Colfax Co.:** NM hwy 72, 11 rd mi E of I-25 (milepost 11), N36.9219 W104.2783, 8200 ft elev., roadside through wooded area, 16 Aug 1998, *Hartman 63481* (RM). **San Miguel Co.:** Santa Fe National Forest and Vicinity: Sangre de Cristo Mountains: NM hwy 263 along Gallinas Creek, 16 air mi NW of Las Vegas, N35.7083 W105.4505, 7750 ft elev., canyon bottom roadside, riparian, and bluffs of volcanic rock in mixed conifer forest, 13 Aug 2002, *Reif 3820* (RM). **Santa Fe Co.:** Santa Fe National Forest and Vicinity: Sangre de Cristo Mountains: Rio Frijoles Trail 154 just E of Santo Domingo de Cundiyo Land Grant, 8 air mi SE of Chimayo, N35.9380 W105.8733, 7000 ft elev., riparian of river, and meadows, in canyon bottom with mixed conifer slopes, 8 Aug 2002, *Reif 3421* (RM).

BETULACEAE

Betula glandulosa Michx.—Furlow (1997) shows this taxon extending down the Rocky Mountains to south-central Colorado. Its presence on the Valles Caldera National Preserve was first noted by Allen (2004) who found numerous stunted birch plants growing on Alamo Bog. This site represents a disjunction of 100 miles or more from the nearest known location in Colorado (http://cumuseum.colorado.edu). Heavy browsing by elk appears to be jeopardizing the population.

Voucher specimens: **Sandoval Co.:** Valles Caldera National Preserve: Jemez Mountains: Alamo Canyon, 1–1.5 mi upstream, N35.9182 W106.6032, 8461ft elev., over 43 healthy but cropped shrubs to 2' tall along 1/4 mi of shoreline on south side, 2 Jun 2003, *Hartman 77223* (RM); 8 Jun 2001, *Jacobs 14* (BAND).

BRASSICACEAE

Cardamine cordifolia A. Gray var. **incana** A. Gray ex M.E. Jones—This markedly pubescent variety is quite distinctive when compared to the essentially glabrous typical one (Rollins 1993; Welsh et al. 2003). Holmgren (2005) does not recognize var. *incana* but notes that the epithet is available for the pubescent form. Previously it was known from Colorado and Utah.

Voucher specimen: **Rio Arriba Co.:** Santa Fe National Forest and Vicinity, Jemez Mountains, upper Cananones Creek and W slope, 11.3 air mi S of Youngsville, N36.0304 W106.5422 to N36.0342 W106.5271, 9300–10000 ft elev., springs on trail in blue spruce/corkbark fir forest with mature aspen, 25 Jun 2002, *Reif 1197* (RM).

Draba grayana (Rydb.) C.L. Hitchc.—This taxon has been considered endemic to Colorado, occurring in its northern and central portions (Rollins 1993). With its discovery on Little Costilla Peak, it is now documented from New Mexico.

Voucher specimen: **Colfax Co.:** Sangre de Cristo Mountains, Carson National Forest-Valle Vidal Unit, Little Costilla Peak, between N36.8260 W105.2234 and N36.8336 W105.2228, 12,231–12,584 ft elev., alpine slopes, 16 Aug 2002, *Hartman 76640* (RM). Determined by Ihsan Al-Shehbaz (MO).

Lepidium ramosissimum A. Nelson var. **bourgeauanum** (Thell.) Rollins—In the western United States, this variety ranges from Montana south to Colorado and west, including Arizona (USDA, NRCS 2006). According to Rollins (1993) "the varieties here recognized are weak at best. The consistently glabrous siliques of var. *bourgeauanum* are not matched by consistency in var. *ramosissimum*, where the siliques are mostly sparsely pubescent, but on occasion both pubescent-fruited and glabrous-fruited plants are found in the same population. The chromosome difference of 2n = 32 for var. *bourgeauanum* and 2n = 64 for var. *ramosissimum*. . . helps to bolster the treatment where the two varieties are recognized. . . ." Holmgren (2005) accepts the two varieties without discussion. We maintain the two taxa pending further study.

Voucher specimens: **Sandoval Co.:** Valles Caldera National Preserve, Jemez Mountains, Jemez Falls Road to turn south, two track and bushwack to southwest corner of Preserve, N35.8277 W106.6170, 8000–8164 ft elev., ponderosa pine forest with rock outcrops and swales, 30 Jul 2001, *Hartman 7313.3* (RM); just S of Sulphur Point, N35.9116 W106.6213, rocky slopes in mixed conifers, 8981 ft elev., 17 Sep 2001, *Hartman 74216* (RM); Alamo Canyon, south side over a mile stretch to near lower end, N35.9117 W106.5992 to N35.9109 W106.5927, 8650–8960 ft elev., scattered at edge of wet area over lower half of boggy portion, 19 Jul 2003, *Hartman 78125* with *Coop* (RM); Puerta de Trasquilar NW up end of Trasquilar, N35.9398 W106.4960 to N35.9423 W106.5002, 8925–9360 ft elev., south exposure with oak and aspen, 24 Jul 2003, *Hartman 78203* . Puerta de Trasquilar NW up end of Trasquilar, N35.9398 W106.4960 to N35.9423 W106.5002, 8925–9360 ft elev, south exposure with oak and aspen, 24 Jul 2003, *Hartman 78234*. (RM); Valle Jaramillo, near "B" and "M" road intersection, N35.9184 W106.4981 to N35.9133 W106.4912, 8705–8720 ft elev., grassy meadow with creek and mud areas on slope with upwelling of water, 24 Jul 2003, *Hartman 78258* (RM); Valle Toledo, crossing of Pipeline Road and San Antonio Creek to 0.4 air mi to NE then S to 0.3 air mi upstream, N35.9602 W106.4827 to N35.9613 W106.4736, 8610–8639 ft elev., wetlands along creek to slopes to N with upwellings (seeps) with barren ground and adjacent "bouncy" ground, 10 Aug 2003, *Hartman 78348* (RM); East Fork Jemez River, short segment in Preserve ca. 1 air mi SW of El Cajete (center of caldera), N35.8277 W106.5751 to N35.8277 W106.5780, 7920–7990 ft elev. along river with blue spruce and white fir on slopes, willow and birch scattered on bank, 11 Aug 2003, *Hartman 78425* (RM); Banco Bonito, 0.8–0.9 air mi NE of southwest corner of Preserve, N35.8385 W106.6136 to N35.8367 W106.6078, 8250–8332 ft elev., roadside through ponderosa pine, 12 Aug 2003, *Hartman 78449* (RM); Pajarito Mountain, ca. 1 air mi WNW of summit, N35.8897 W106.4172 to N35.8897 W106.4173, 8970–9050 ft elev., lower grassy slopes to scattered ponderosa pine, 21 Aug 2003, *Hartman 78802* (RM); off of G Road just above F Road, ca. 1 air mi N of Cerro Santa Rosa, just N of Valle San Antonio, N35.9743 W106.5050, 8560–8800 ft elev., logged ponderosa pine forest, 5 Aug 2003, *Nelson 59659* (RM); Jemez Mountains, from 3/4 mi E to N35.9775 W106.4827 in Rito de los Indios drainage, 8750–9000 ft elev., disturbed areas, 5 Aug 2003, *Nelson 59700* (RM); from tributary of Rito de los Indios NW to summit of ridge, ca. 1 1/2–1 3/4 air mi N of north summit of Cerros de Trasquilar, N35.9921 W106.5020, 9100–9740 ft elev., open, grassy slopes with scattered ponderosa pine, 5 Aug 2003, *Nelson 59757* (RM); along G Road ca. 1 3/4 mi N of F Road, ca. 2 1/2–2 3/4 air mi N of Cerro Santa Rosa, N35.9978 W106.5006, 9600–9800 ft elev., meadow, 5 Aug 2003, *Nelson 59831* (RM); on the ridge W of Valle Grande, ca. 1 1/4–1 3/4 air mi N of Ranch Headquarters, N35.8806 W106.5180, 8900–9600 ft elev., roadside through mixed conifer forest, 7 Aug 2003, *Nelson 59942* (RM); ridge S and E of Valle Jaramillo, ca. 1 air mi NW of Cerro Piñon, N35.8993 W106.5124, 9400 ft elev., clearcut Douglas fir forest with mostly blue spruce/white fir regeneration, 10 Aug 2003, *Nelson 60025* (RM); along K Road at the northeast base of San Antonio Mountain, N35.9449 W106.5925 to N35.9437 W106.5989, 8900–9100 ft elev., roadside and adjacent open mixed conifer/aspen forest, 11 Aug 2003, *Nelson 60082* (RM); along the northeast and north side of San Antonio Mountain to the west boundary, N35.9437 W106.5989 to N35.9463 W106.6204, 9000–9350 ft elev., along old logging road, mixed conifer/aspen forest, and clearings, 11 Aug 2003, *Nelson 60118* (RM); on the east slope of Cerros del Abrigo above the Abrigo Trail for 0.3 mi on either side, N35.9301 W106.4726, 9500–10200 ft elev., along old logging road, slopes in open mixed conifer/aspen forest, and open areas,13 Aug 2003, *Nelson 60314* (RM); on the south side of Cerros del Abrigo along the Abrigo Trail for 0.3 mi on either side, N35.9232 W106.4768, 9400 ft elev., along old logging road, roadcut, and adjacent southwestern white pine/white fir/Douglas fir forest. 13 Aug 2003. *Nelson 60243* (RM); **Santa Fe Co.:** Santa Fe National Forest and Vicinity, Sangre de Cristo Mountains, Rio Frijoles Trail 154 just E of Santo Domingo de Cundiyo Land Grant, 8 air mi SE of Chimayo, N35.9380 W105.8733, 7000 ft elev., riparian of river, and meadows, in canyon bottom with mixed conifer slopes, 8 Aug 2002, *Reif 3448* (RM).

Rorippa sylvestris (L.) Besser—Introduced throughout much of the United States, this mustard is said to occur in New Mexico: "reported questionably by Kartesz and Meacham (1999); awaits verification" Allred (2005).

Voucher specimen: **San Miguel Co.:** Santa Fe National Forest and Vicinity, Sangre de Cristo Mountains, Anton Chico Grant, 5 air mi ENE of Villanueva, along Pecos River, 35.2365 105.2558, 5500 ft elev., river bottom, mostly juniper with Russian olive and narrowleaf cottonwood, 6 Aug 2004, *Reif 10067* (RM).

CYPERACEAE

Carex deweyana Schwein. var. **deweyana**—Naczi (2002) lists but does not map this taxon for New Mexico, although it is mapped for the state in USDA, NRCS (2006). Interestingly, it is not included in Allred (2005). Regardless, the first two sources do not contain voucher data. Consequently, our records are provided below.

Voucher specimens: **Los Alamos Co.:** Santa Fe National Forest and Vicinity, Jemez Mountains, lower Guaje Canyon and Cabra Canyon, 3 air mi N of Los Alamos, N35.9310 W106.3432 to N35.9064 W106.2862, 7000–8017 ft elev., riparian drainage through mixed conifer forest, into a burn past the canyon, and then a ponderosa pine forest before joining the road, 28 Jun 2002, *Reif 1475* (RM). **Santa Fe Co.:** Santa Fe National Forest and Vicinity, Sangre de Cristo Mountains, Pecos Wilderness, Rio Medio Trail 155 adjacent to Rio Medio, 6 air mi due W of Truchas Peak, N35.9630 W105.7520, 8410 ft elev., riparian corridor through spruce of lower canyon slopes, banks of river or standing water, 23 Jun 2003, *Reif 5806* (RM).

Carex rosea Schkuhr ex Willd. According to Ball (2002), this taxon ranges from Wyoming, the Great Plains and Texas to the east coast of North America.

Voucher specimens: **Sandoval Co.:** Santa Fe National Forest and Vicinity, Jemez Mountains, Cochiti Canyon, 4.3 air mi SSE of Rabbit Mountain, N35.7794 W106.4366 to N35.7645 W106.4266, 7200–8280 ft elev., canyon bottom and riparian, 23 Jun 2003, *Reif 1116* (RM). **San Miguel Co.:** Santa Fe National Forest and Vicinity, Sangre de Cristo Mountains, Sebadilla Creek S of Flying Cloud Ranch, 3 air mi SSW of Barillas Peak, up creek 1/2 air mi, N35.5320 W105.4920, 7740–7880 ft elev., narrow riparian corridor in canyon bottom, canyon surrounded by mixed conifer forest, granite bluffs and bedrock constrictions, 9 Jun 2003, *Reif 5070* (RM); El Porvenir Canyon on Trail 247, 5 air mi W of San Ignacio, N35.770 W105.448, 8200–8450 ft elev., canyon bottom of mostly spruce, and moist lower slope of mixed conifers along trail, granite bluffs constricting canyon, 6 Jul 2003, *Reif 6183* (RM).

EQUISETACEAE

Equisetum ×nelsonii (A.A. Eaton) J.H. Schaffn.—This plant represents a spontaneous hybrid between *E. laevigatum* and *E. variegatum*. The former putative parent is frequent in the Jemez Mountains; *E. variegatum* is not documented from New Mexico but has been collected as far south as Montezuma County, Colorado, some 130 mi to the northwest. In the Rocky Mountains, the hybrid is known from Montana, Wyoming, Utah, and Colorado (USDA, NRCS 2006).

Voucher specimen: **Sandoval Co.:** Bandelier National Monument, White Rock Canyon at mouth of Alamo Canyon along banks of Rio Grande, N35.7146 W106.2907, 5300 ft elev., 23 Aug 1975, *Foxx s.n.* (BAND).

JUGLANDACEAE

Juglans nigra L.—Black walnut, a native of the eastern United States, has been cultivated in areas of the western United States. As described below, it is naturalized in NM.

Voucher specimens: **Sandoval Co.:** Bandelier National Monument, vicinity of Park Headquarters in Canyon de los Frijoles, along Rito de los Frijoles near and below Tyuonyi Ruin. N35.7839 W106.2772, 6,100 ft elev., escaped third generation seedlings scattered in cottonwood bosque along stream, 21 Sep 2003, *Jacobs 5083* (BAND), second generation tree bearing fruit, seed source is a planting in historic Frey Abbott orchard, 4 May 2003, *Jacobs 5084* (BAND).

OLEACEAE

Syringa vulgaris L.—This introduced lilac occurs over much of eastern United States and scattered states in the West. The latter includes Kansas, Colorado, and Utah (USDA, NRCS 2006). This collection appears to be an adventive representing the first New Mexico record.

Voucher specimen: **Santa Fe Co.:** Santa Fe National Forest and Vicinity, Sangre de Cristo Mountains, Tesuque Creek on Winsor Trail 254, 3 air mi SE of Tesuque, N35.745 W105.888 SW to N35.743 W105.896, 7320–7370 ft elev., narrow canyon bottom and riparian with mature ponderosa pine, horsetail, cottonwood, alder, and willow, granitic soils, 12 Jun 2003, *Reif 5252* (RM).

POACEAE

Achnatherum nelsonii Scribn. var. **nelsonii**—According to Barkworth et al. (1979), this grass ranges from southern Montana and central Idaho south through Nevada and Utah. In Utah it has been documented in the southeast corner, immediately adjacent to New Mexico. In addition, USDA, NRCS (2006) maps it for Colorado and Arizona. Verified by Mary E. Barkworth.

Voucher specimens: **Rio Arriba Co.**: Santa Fe National Forest and Vicinity, Jemez Mountains, vicinity of Presa Spring on southern edge of Chama River Canyon Wilderness, 8 air mi NE of Gallina, N36.3120 W106.7340, 8340 ft elev., a forest of mature ponderosa pine, with thickets of Gambels oak and grassy open areas below, 19 Jun 2003, *Reif 5617* (RM). **Sandoval Co.**: Sierra Nacimiento, Joaquin Canyon, ca. 2 3/4–3 1/4 air mi W of Rio Guadalupe, N35.7937 W106.8307, 7850–8050 ft elev., open area along logging road and adjacent mixed conifer forest, 20 Jul 2004, *Nelson 62160* (RM).

Cynosurus echinatus L. This grass has been introduced in much of eastern United States, the West Coast, and Montana (USDA, NRCS 2006). This represents the first report of its establishment in New Mexico.

Voucher specimen: **Sandoval Co.**: Bandelier National Monument, Capulin Canyon, ca. 0.25 mi S of Base Camp, near where trail to Stone Lions joins canyon trail, N35.7541 W106.3262, 6100 ft elev., dense stand along stream, 13 Jun 1988, *B. Jacobs 4167* (BAND).

Piptatherum pungens (Torr. ex Spreng.) Dorn—This species ranges across western Canada and south in the Black Hills of Wyoming and South Dakota to the central cordillera of Colorado (Kartesz and Meacham 1999, USDA, NRCS 2006). In Colorado it is documented from Douglas, Grand, and Saguache cos. (http://cumuseum.colorado.edu). The distance from the nearest locality in Saguache Co. is about 150 miles.

Voucher specimen: **Sandoval Co.**: Valles Caldera National Preserve, Jemez Mountains, Cerros del Trasquilar, main portion, N35.9648 W106.4918, 8537–8740 ft elev., roadside and coniferous forest, 26 Jun 2001, *Hartman 71472* (RM).

RANUNCULACEAE

Ranunculus alismifolius Geyer ex Benth. var. **montanus** S. Watson—According to Whittemore (1997), this taxon is restricted to southwestern Colorado, Idaho, Nevada, Utah, and Wyoming. It is one of six varieties recognized by this author, all of which occur from the Rocky Mountains to the west coast of North America. These specimens document its occurrence in New Mexico.

Voucher specimens: **Rio Arriba Co.**: San Pedro Mountains, N 36.0667 W106.8433, 10200 ft elev., seep under aspen and spruce, 4 Jul 2001 *Dorn 8829* (RM); Santa Fe National Forest and Vicinity, Jemez Mountains, Forest Road 70 and Forest Road 50, Padomas Trail, NW into San Pedro Parks Wilderness to Vacas Trail, Forest Road 51, N36.0421 W106.7924 to N36.0662 W106.8121, 9300–10135 ft elev., ponderosa pine and some spruce, 20 Jun 2002, *Hartman 75015* (RM); Rito de Abiquiu NE of Cienega del Oso, 2.5 air mi SSE of Polvadera Peak, N36.0290 W106.3900 to N36.0360 W106.3820, 9400–10430 ft elev., open riparian bottom and steep shaded slope of corkbark fir/blue spruce with an understory of Paxistima, Trauttvetaria, and Vaccinium, 12 Jul 2003, *Reif 6567* (RM); NM hwy 70, South San Pedro Parks Wilderness trailhead from parking lot N to San Gregorio Reservoir, 36.0273 N106.8469 to W36.0407 106.8460, 9200–9400 ft elev., open wet meadows in mixed coniferous forest with aspen, 2 Jun 2002, *Reif 45* (RM).

Ranunculus repens L.—This taxon is naturalized throughout much of the eastern and western portions of the United States (Whittemore 1997). The two collections cited below also appear to represent self-maintaining populations.

Voucher specimens: **Sandoval Co.**: Santa Fe National Forest and Vicinity, Jemez Mountains, 8 air mi SW of La Cueva, Forest Road 376, 2 air mi N of Porter, N35.8442 W106.7810, 7490 ft elev., stream and adjacent meadow, 23 Jun 2002, *Hartman 75232* (RM). **San Miguel Co.**: Sangre de Cristo Mountains, Forest Road 60 along Sapello River, 2 air mi SW of Rociada. N35.8129 W105.4480, 8000 ft elev., canyon bottom parking area at corral and trailhead, including riparian of river and south-facing bank (below road) of mature aspen with Gambels oak, 18 Aug 2003, *Reif 8741* (RM)

ROSACEAE

Geum triflorum Pursh var. **triflorum**—Holmgren (1997) states that var. *triflorum* ranges south in the Rocky Mountains, where it more or less straddles the continental divide from Montana to northern New Mexico and includes some populations as far west as

northeastern Arizona. The following specimens document its occurrence in New Mexico. Variety *ciliatum*, the more western version of the species is listed for New Mexico by Allred (2005).

Voucher specimens: **Colfax Co.:** Philmont Scout Ranch, Beaubien, N36.4237 W105.1033, 9400 ft elev., common on dry, grassy slopes, 27 Jun 1966, *Hartman 117* (RM); 6 Jun 1968, *Hartman 1819* (RM); **Rio Arriba Co.:** Carson National Forest, Canyon Bancos ca. 14 air mi W of Dulce, 36.9008 107.2237 to 36.9143 107.2690, 6900–7150 ft elev., stream floodplain and adjacent sandstone mesas with pinyon-juniper, 28 May 1987, *Hartman 22504* with *D'Alcamo* et al. (RM). **Sandoval Co.:** Jemez Mountains, East Fork Jemez River, ca. 0.5 mi above Las Conchas Campground, N35.8200 W106.5212, 8500 ft elev., 18 Jun 1986, *Jacobs 006* with *Jacobs* (RM).

Potentilla fissa Nutt.—This species is common throughout the Rocky Mountains and several adjacent states; likewise it is included for New Mexico (USDA, NRCA 2006). Allred (2005) indicates that it is reported for New Mexico but awaits verification.

Voucher specimen: **San Miguel Co.:** Santa Fe National Forest and Vicinity, Sangre de Cristo Mountains, Hermit Peak, N35.7447 W105.4139, 10000–10212 ft elev., open grassy and rocky areas and rim rock, 18 Aug 2002, *Hartman 76734* (RM).

Prunus persica (L.) Batsch—The introduced peach is known from much of the eastern United States and several of the states to the west, but it is not reported from Montana south to New Mexico (USDA, NRCS 2006). In both localities here listed, it was found growing in sites devoid of human disturbance and thus appears to be adventive.

Voucher specimens: **Sandoval Co.:** Valles Caldera National Preserve, Jemez Falls Road to turn south, N35.8277 W106.6170, 8000–8164 ft elev., ponderosa pine forest with rock outcrops and swales, 30 Jul 2001, *Hartman 73177* (RM); Santa Fe National Forest and Vicinity, Jemez Mountains, Battleship Rock Trail 137 at McCauley Warm Springs, N35.8222 W106.6281, 7300–7400 ft elev., warm springs and riparian drainage in ponderosa pine forest, 1 Sep 2003, *Reif 9380* (RM).

SAXIFRAGACEAE

Heuchera hallii A. Gray—This taxon was considered by Rosendahl et al. (1936) as distinctive. It has been considered to be endemic to Colorado; in the vicinity of Pikes Peak (Chaffee, Custer, Douglas, El Paso, Jefferson, and Park cos.). (http://cumuseum.colorado.edu). These reports represent a range extension of about 90 miles to the south.

Voucher specimens: **Colfax Co.:** Philmont Scout Ranch, Rayado Canyon, 0.5 mi W of Old Abreu Lodge, N36.3765 W105.0331, 7500 ft elev., sandy stream bank and rock outcrop, 15 Jul 1968, *Hartman 2385* (RM); base of Crater Peak along Rayado River, ca. 2 air mi SE of Fish Camp, N36.3746 W105.0380, 8200–8800 ft elev., slope above river 10 Jul 1991, *Embry 92a* with *Hartman* (RM); 4 Aug 1991, *Embry 92b* (RM).

SCROPHULARIACEAE

Penstemon glaber Pursh var. **alpinus** (Torr.) A. Gray—This variety is the second for the species to be documented in New Mexico. Its previous known range was southeastern Wyoming to south-central Colorado (Great Plains Flora Association 1986, see key to varieties). Variety *brandegeei* (T.S. Porter & Rydb.) C. Freeman had been the only taxon of this species documented for New Mexico.

Voucher specimens: **Los Alamos Co.:** Santa Fe National Forest and Vicinity, Jemez Mountains, Mitchell Trail 69, from Los Alamos, NW 2.1 air mi to Guaje Reservoir, N35.9310 W106.3432, 7500–8900 ft elev., incised gravel streambed through a burn, climbing canyon walls of tuft and rhyolite, to a mixed conifer forest with patchy burns, 28 Jun 2002, *Reif 1379* with *Hartman* and *Jacobs* (RM); **Taos Co.:** Carson National Forest and Vicinity, Sangre de Cristo Range, Valle Vidal Unit, ridgeline above corral from Forest Road 1950 toward Little Castilla Peak, N36.7843 W105.2330, 10,000–12,584 ft elev., spruce fir and bristlecone pine forest with meadow openings, rocky ridgeline, 30 Jul 2005, *Larson 3373* (RM).

ACKNOWLEDGMENTS

The authors thank the following individuals for verification of specimens: Mary Barkworth, Utah State University; Ihsan A. Al-Shehbaz, Missouri Botanical Garden. Also thanked are Kelly W. Allred, Guy L. Nesom, and Richard W. Spellenberg for their helpful comments on the manuscripts. We thank Jill Larson, M.S. student (RM), for allowing us to publish her record of *Penstemon glaber* var. *alpinus*.

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Books Received

John F. Leslie and Brett A. Summerell, Photographs by Suzanne Bullock. 2006. **The Fusarium Laboratory Manual.** (ISBN 0-8138-1919-9, pbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. (**Orders:** 515-292-0140, 515-292-3348 fax 1-800-862-6657, www.blackwellprofessional.com, orders@ames.blackwellpublishing.com,). $124.99, 388 pp., numerous b/w illustrations, 8 1/2" × 11".

From the Publisher.—"For the first time in over 20 years, a comprehensive collection of photographs and descriptions of species in the fungal genus *Fusarium* is available. This laboratory manual provides an overview of the biology of *Fusarium* and the techniques involved in the isolation, identification and characterization of individual species and the populations in which they occur. It is the first time that genetic, morphological and molecular approaches have been incorporated into a volume devoted to *Fusarium* identification. The authors include descriptions of species, both new and old, and provide protocols for genetic, morphological and molecular identification techniques."

"The Fusarium *Laboratory Manual* also includes some of the evolutionary biology and population genetics thinking that has begun to inform the understanding of agriculturally important fungal pathogens. In addition to practical "how-to" protocols it also provides guidance in formulating questions and obtaining answers about this very important group of fungi. The need for as many different techniques as possible to be used in the identification and characterization process has never been greater. These approaches have applications to fungi other than those in the genus *Fusarium*. This volume presents an introduction to the genus *Fusarium*, the toxins these fungi produce and the diseases they can cause."

Kris M. Havstad, Laura F. Huenneke, and William H. Schlesinger. (eds.). 2006. **Structure and Function of a Chihuahuan Desert Ecosystem. The Jornada Basin Long-Term Ecological Research Site.** (ISBN 978-0-19-511776-9, hbk.). Oxford University Press, 2001 Evans Road, Cary, NC 27513, U.S.A. (**Orders:** 800-451-7556; http://www.oup.com). $74.50, 465 pp., b/w halftones, maps and line illustrations, 6 1/8" × 9 1/4".

From the Publisher.—"The Jornada Basin LTER is located in the Chihuahan Desert, the largest in North America. This region of south central New Mexico has a history of nearly 100 years as the basis for scientific research. This work gives a thorough, encompassing review of the tremendous array of observations resulting from experiments conducted in this ecosystem. Beginning with thorough descriptions of the most salient features of the region, the book then reviews a wide range of archived and active data sets on a diversity of biotic and abiotic features. It next presents a syntheses of important topics including livestock grazing and remediation efforts. A concluding chapter provides a synthesis of the principles that have emerged from this body of work, and how these relate to the broader fields of ecology and natural resource management. It concludes with recommendations for future research directions. The insightful views expressed in this volume should guide management of arid landscapes globally. This is the sixth volume in the Long Term Ecological Network Series.

GALIUM TRICORNUTUM (RUBIACEAE) AND *PARENTUCELLIA VISCOSA* (SCROPHULARIACEAE) NEW TO OKLAHOMA

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ABSTRACT

This paper reports the occurrence of two species previously unknown to the flora of Oklahoma. *Galium tricornutum*, a Eurasian introduction, was discovered in a cement drainage ditch in Hughes County in central Oklahoma. *Parentucellia viscosa*, an introduction from Europe, was discovered in disturbed grassland in McCurtain County in extreme southeastern Oklahoma.

RESUMEN

Este artículo cita la ocurrencia de dos especies previamente desconocidas de la flora de Oklahoma. *Galium tricornutum*, una introducción eurasiática, fue descubierta en una zanja de drenaje de cemento en el condado de Hughes en el centro de Oklahoma. *Parentucellia viscosa* (L.) Caruel, una introducción de Europa, fue descubierta en un prado alterado en el condado de McCurtain en el extremo sudeste de Oklahoma.

Galium tricornutum Dandy, in the Rubiaceae, is an introduced annual herb native to Eurasia that is typically found in waste places and as a weed of cereal crops. It has been reported previously in Arksansas, California, Georgia, New York, Oregon, Pennsylvania, Rhode Island, South Carolina, Washington, Wisconsin, and Oregon (USDA-NRCS 2006). One plant was encountered growing in a crack in a cement drainage ditch in the Holdenville city park in central Oklahoma. The combination of recurved pedicels and a tuberculate fruit distinguish *G. tricornutum* from other weedy *Galium* species in Oklahoma.

Voucher specimen for ***Galium tricornutum***: **OKLAHOMA. Hughes Co.:** Holdenville, at Stroup City Park, T7N R9E sec18, 11 May 2006, *Buthod, Hoagland, and Crawford AB-7138*(OKL).

Parentucellia viscosa (L.) Caruel, in the Scrophulariaceae, is an introduced annual herb native to Europe typically found on moist, grassy places and frequently in old meadows. It has been reported in Arkansas, California, Hawaii, Louisiana, Oregon, Texas, and Washington (USDA-NRCS 2006). Only one plant was located in a disturbed tallgrass prairie site on limestone in southeastern Oklahoma. Associated species included *Centaurea americana* Nutt., *Echinacea atrorubens*, *Sorghum halepense* (L.) Pers., and *Rudbeckia hirta* L.

Voucher specimen for ***Parentucellia viscosa***: **OKLAHOMA. McCurtain Co.:** 1.9 mi NWof Idabel, T7S R23E SE/4 sec 25, 25 May 2006, *Buthod, Hoagland, and Arbour AB-7137*(OKL).

ACKNOWLEDGMENTS

We appreciate the field assistance of David Arbour and Priscilla Crawford and the comments of Susan Barber and Ron Tyrl.

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ANNOUNCEMENTS

2006 Delzie Demaree Travel Award Recipients

The 18th Annual Delzie Demaree Travel Award was presented at the 52nd Annual Systematics Symposium (13–14 Oct 2006) at the Missouri Botanical Garden. Three students were presented the Travel Award: **Alejandra Vasco,** New York Botanical Garden and City University; **Diana Hurlbut,** Central Michigan University; and **Michael Sundue,** New York Botanical Garden and City University.

The 2006 Travel Awards were underwritten by **1)** Delzie Demaree Travel Award Endowment, **2)** Members of the Delzie Demaree Travel Award Committee, and **3)** John Clayton Chapter of the Virginia Native Plant Society.

Anyone interested in making a contribution to Delzie Demaree Endowment Fund, which supports the travel award, may make contributions by VISA or MasterCard or by a check, payable to Botanical Research Institute of Texas, to Barney Lipscomb, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A. 1-817-332-7432; Email: barney@brit.org. Thank you.

The 2007 Applications for the Delzie Demaree Travel Award

Applications for the 2007 Delzie Demaree Travel Award should include a letter from the applicant telling how symposium attendance will benefit his/her graduate work and letter of recommendation sent by the major professor. Please send letters of application to: Dr. Donna M.E. Ware, P.O. Box 8795, Herbarium, Biology Department, The College of William and Mary, Williamsburg, VA 23185-8795, U.S.A. 1-757-221-2799; Email: ddmware@wm.edu. The period for receiving applications will end three weeks prior to the date of the symposium if a sufficient number of applications are in hand at that time. Anyone wishing to apply after that date should inquire whether applications are still being accepted before applying. The Systematics Symposium dates for 2007 are 12–13 October 2007.

The Delzie Demaree Travel Award was established in 1988 and honors **Delzie Demaree** who attended 35 out of a possible 36 symposia before he died in 1987. Delzie Demaree was a frontier botanist, explorer, discoverer, and teacher. His teaching career as a botanist began in Arkansas at Hendrix College in 1922. He also taught botany at the University of Arkansas, Navajo Indian School, Yale School of Forestry, Arkansas A&M, and Arkansas State University at Jonesboro where he retired as professor emeritus in 1953. One of the things he enjoyed most as a botanist was assisting students with their field botany research.

CAPRARIA MEXICANA (SCROPHULARIACEAE) IN CAMERON COUNTY, TEXAS: REDISCOVERED IN THE UNITED STATES

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ABSTRACT

Two new sites are reported for *Capraria mexicana* (Scrophulariaceae) in the United States.

RESUMEN

Se reportan dos nuevos sitios para *Capraria mexicana* (Scrophulariaceae) en los Estados Unidos.

Capraria mexicana (Mexican Capraria) is an attractive shrub reaching 2 m in height (Fig. 1). The leaves are alternate, lanceolate, with serrate margins. The flowers emerge from the leaf axils. Corollas are regular, white, basally sympetalous, with lobes about 9 mm long. Everitt et al. (2002) provide description and a picture. Most reports of *C. mexicana* are from Tamaulipas, Mexico, with records also from Jalisco, Guerrero, and Tabasco. The southernmost collections are from Belize (Ideker 1996).

Capraria mexicana was first discovered in the United States by Joe Ideker in 1993. He reported at least 66 mature plants plus seedlings in three small stands located at Falcon State Park near the International Falcon Reservoir in Starr County, Texas. (Ideker 1996). The plants were in a precarious location where they could be flooded with a rise in the reservoir, and they were located within a proposed drilling pad site. After communication with Joe Ideker in 1993, this species was listed as Endangered in Texas by the Texas Organization for Endangered Species (TOES). It is not considered Endangered in Mexico. Our attempt to relocate the population on 25 March 2006 was unsuccessful. Benito Trevino, well known authority on plants of Starr County, reported having seen no *Capraria* plants when he had visited the site.

In September of 2005, while at the Laguna Atascosa National Wildlife Refuge, Cameron County, Texas, we were shown a single plant of *Capraria mexicana* by Ellie Thompson, volunteer manager of the butterfly garden there. She had watched it grow from a volunteer seedling to maturity. As no nearby members of the species were known, it was assumed to be an inadvertent introduction from Starr County nursery stock.

In March of 2006, we observed a large population of *Capraria mexicana* in Brownsville, Cameron County, Texas, along Highway 511, 0.4 miles north of Old Port Isabel Road. The population continued for at least 0.2 miles. The population is estimated to comprise several hundred individuals ranging from 0.3 m to 1.2 m tall The plants were seen growing on both sides of the highway, on saline clay, with *Opuntia engelmannii* var. *lindheimeri*, *Borrichia frutescens*, *Prosopis glandulosa* var. *glandulosa*, *P. reptans*, *Maytenus phyllanthoides*, *Fleischmannia incarnata*, *Dichanthium* sp., and *Bothriochloa* sp.

With the presumed extirpation of the population at Falcon State Park, the Brownsville

SIDA 22(2): 1237– 1238. 2006



FIG. 1. *Capraria mexicana* photographed in Cameron County, Texas, along Highway 511, 0.4 mile north of Old Port Isabel Road.

site is the only confirmed population of *Capraria mexicana* in the United States. Further surveys might reveal a population at Laguna Atascosa National Wildlife Refuge. The plants can be easily overlooked if not in flower, since the leaves greatly resemble those of *Baccharis*.

Voucher specimen: **TEXAS. Cameron Co.:** Brownsville, Hwy 511, 0.4 mi N of Old Port Isabel Road, 16 Mar 2006, *Richardson and King 3284* (BRIT, TEX).

ACKNOWLEDGMENTS

We thank Mike Heep for identification of the grasses, and an anonymous reviewer who provided useful and constructive comments.

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TEXAS ORGANIZATION FOR ENDANGERED SPECIES (TOES). 1993. Endangered, threatened and watch lists of Texas plants. TOES Publ. 9, 3d. rev (and 1993 addenda).

RANGE EXPANSION OF *HEXALECTRIS GRANDIFLORA* (ORCHIDACEAE) IN TEXAS

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ABSTRACT

Plants of *Hexalectris grandiflora* A. Richard & Galeotti (Orchidaceae) collected in Dallas County, Texas in 2005 and 2006 extend the range of this species northeast by more than 700 km and indicates greater diversity for the genus *Hexalectris* in Dallas County than previously observed. These observations suggest either the absence of sufficient data on this species' range in intervening counties, or the loss of populations between the north central Texas and western Texas locations, and argue for continued study of *Hexalectris* throughout the state.

ABSTRACT

Las plantas de *Hexalectris grandiflora* A. Richard & Galeotti (Orchidaceae) colectadas en el condado de Dallas, Texas en 2005 y 2006 aumentan el área de esta especie hacia el noreste más de 700 km e indican mayor diversidad para el género *Hexalectris* en el condado de Dallas de la que se había observado previamente. Estas observaciones sugieren tanto la ausencia de datos suficientes del areal de esta especie en los condados afectados, o la pérdida de poblaciones entre el norte-centro de Texas y las localidades del oeste de Texas, y se aportan argumentos para continuar el estudio de *Hexalectris* en todo el estado.

The myco-heterotrophic orchid genus *Hexalectris* Rafinesque is comprised of seven species—five that are found in the United States and two that are found only in Mexico (Goldman et al. 2002). Four of the species found in Texas are *H. grandiflora* A. Richard & Galeotti, *H. warnockii* Ames & Correll, *H. nitida* L.O. Williams, and *H. revoluta* var. *revoluta* Correll (*H. revoluta* var. *colemanii* Catling) has recently been described from Arizona (Catling 2004). The fifth species found in Texas, *H. spicata* (Walter) Barnhart, includes two varieties: *H. spicata* var. *spicata* and *H. spicata* var. *arizonica* (S. Watson) Catling & Engel . *Hexalectris spicata* var. *spicata*. ranges widely from Arizona through the southeastern US and north to Maryland, and *H. spicata* var. *arizonica*, revalidated in 1993, is found only in parts of Texas and Arizona (Catling & Engel 1993).

Dallas County has recorded populations of *H. spicata* var. *spicata*, *H. spicata* var. *arizonica*, *H. warnockii*, and *H. nitida* (Diggs et al. 1999; Hatch et al. 1990). Dallas County populations of *Hexalectris* are found in areas of the White Rock Escarpment, a geological region of lower Cretaceous limestone that extends northeast from Dallas to the Oklahoma border, and southwest past Waco and Austin into the Edwards Plateau (Dallas Department of Urban Planning 1977). The escarpment geological zone, known for its distinctive flora, is most evident in the southwestern part of the county, and it is in this area where most of the Dallas County plants of *Hexalectris* have been found (Collins et al. 2005). Studies in Dallas County examined habitat structure and soil association for *Hexalectris*. They indicate an association with oak litter (generally *Quercus buckleyii* or *Q. shumardii)* mixed with *Juniperus* spp. and distributed primarily on Dallas soil series Eddy-Brackett complex (8–20 % slope) (Collins et al. 2005). Ongoing work attempts to

confirm this soil-orchid relationship through targeted searches in preserved habitat areas with Eddy-Brackett soils that are well-drained and have sufficient slope.

Intensive studies of *Hexalectris* distribution in 2005 and 2006 led to the discovery of *H. grandiflora*, a species not previously found in Dallas County. On 21 June 2005, during *Hexalectris* studies on the focal soil series,a cluster of *H. grandiflora* was identified at Camp Wisdom, a 344-acre tract of escarpment habitat in southwest Dallas County owned and operated by the Circle 10 Council of Boy Scouts of America as an educational and camping site. One cluster of six aboveground stems was found during a comprehensive search of the location (Fig. 1). The stems were erect, leafless, and slender, pinkish red at base, and becoming lighter toward the inflorescence. The dorsal sepals were oblong to elliptic; white to pale pink at base, and light pink distally. The lateral sepals were falcate, white to pale pink at base and light pink distally. The petals were recurved, white to pale pink at base and light pink distally. The column was pink with a white tip and the lip (labellum) was lobed and lamellate. The lateral lobes were deep pink, and the middle lobe was pink at the margin and white at the center. Stems were found in an area dominated by *Quercus* spp. and *Juniperus* spp., although the plants were found directly below a rusty blackhaw viburnum (*Viburnum rufidulum*). Fifteen blooming stems were noted on 9 June 2006 at the same location, and were observed to be more robust than when first sighted in 2005.

A second population of *Hexalectris grandiflora* was found at Cedar Ridge Preserve in 2006 approximately 5.5 km southwest of the 2005 sighting. A cluster of 9 stems was observed on 13 May 2006. Definitive identification of the species was possible on 2 June 2006 when the plants were blooming (Fig. 2). These *Hexalectris* stems were immediately adjacent to one of the preserve's trails in an area dominated by *Quercus* spp. and *Juniperus* spp, and with a somewhat open canopy due to a trail cut. Only half of the individuals survived to flowering, due to losses from trail use and inadvertent trampling of the small stems.

Specimens (Fig. 3) from the Camp Wisdom and Cedar Ridge locations were deposited at the herbarium at the Botanical Research Institute of Texas in Fort Worth (BRIT). In addition, tissue from the plant stem and roots was sampled at both locations for genetic analysis as part of a study of phylogeny, evolution and mycorrhizal specificity in *Hexalectris* orchids (A. Kennedy, pers. comm.)

Voucher specimens: **Texas. Dallas Co.:** Camp Wisdom (6400 Redbird Ln.), Escarpment habitat, Eddy-Brackett soil series, N 32 40.552', @ 96 56.640, elev. 730 ft, 21 Jun 2005, *M. Brown-Marsden and A. Collins s.n.* (BRIT); Cedar Ridge Preserve, White Rock Escarpment, Dallas Park and Recrreation/Dallas County Open Space property, N 32° 37.656 W 096°, elev. 711 ft., mixed oak juniper woods, ground cover primarily juniper and oak leaves, some bare rock, adjacent to trail, one of nine stems seen emerging on 13 May 2006, first blooms 2 Jun 2006, *M. Brown-Marsden s.n.* (BRIT).

In Texas, *Hexalectris grandiflora* has previously been documented only within the Davis and Chisos Mountains of extreme western Texas at elevations of 700–2500 m (Goldman et al. 2002). Confirmation of *H. grandiflora* in Dallas County marks both a significant disjunct in its distribution, and deviation from previously described habitat types. The plants found at the Camp Wisdom and Cedar Ridge sites were at elevations of 217 and 243 m, respectively. They were found in woodlands dominated by oak and juniper, but lacking the pinyon pine of the extreme west Texas part of its normal range. In spite of these deviations from the range and habitat of conspecific populations, they were still found on the same soil types as other members of the genus throughout Dallas County

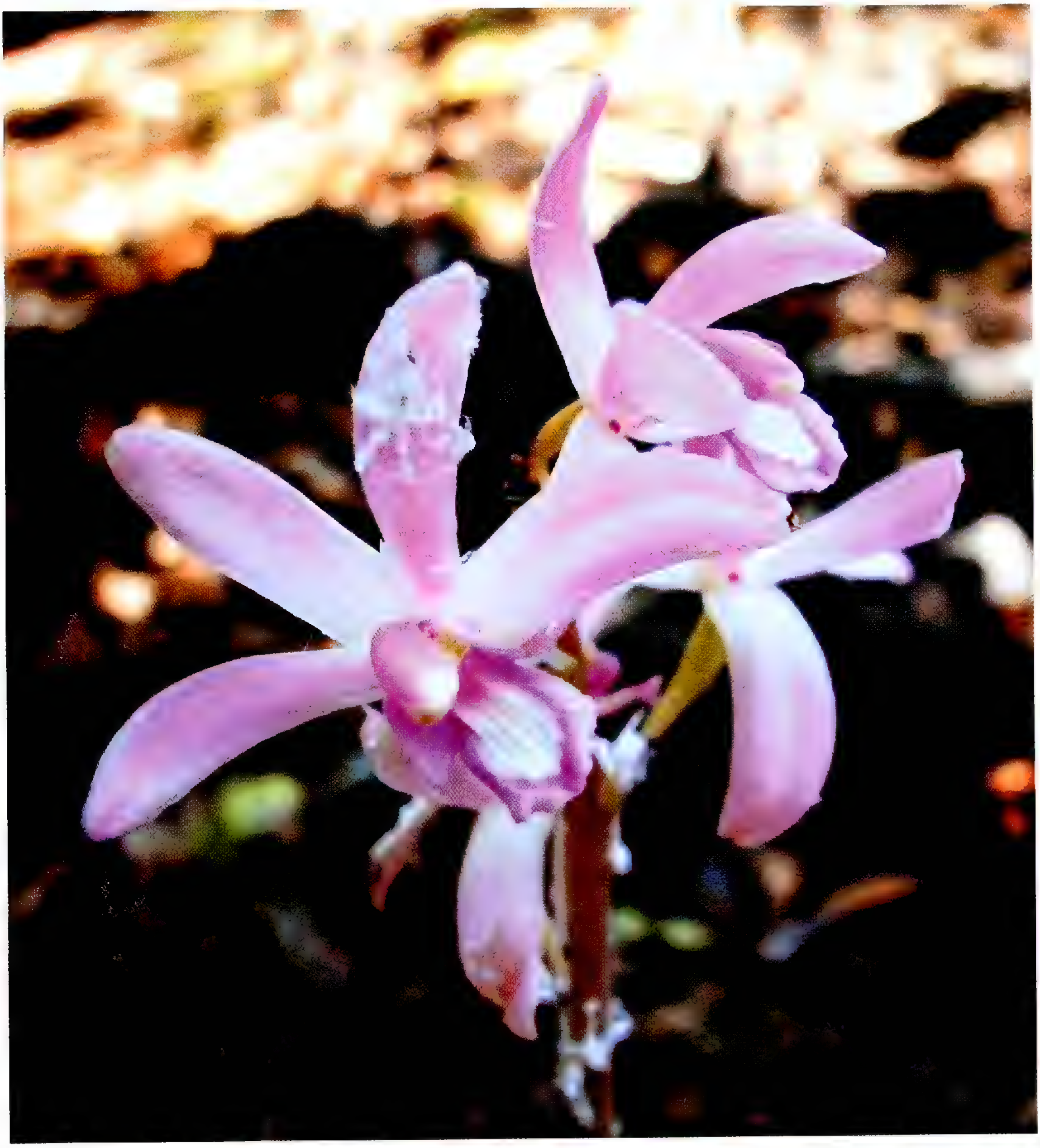


FIG. 1. Photograph of *Hexalectris grandiflora* inflorescence at Camp Wisdom, Dallas County, Texas on 21 June 2005. Photo by Randy Schoen.

(Collins et al. 2005). Additionally, all observations of *H. grandiflora* have occurred within years of moderate to severe drought, and have been the driest years on record since 1963–1964 (Drought Preparedness Council report, March 2006).

The discovery of this significant disjunct in the range of *Hexalectris grandiflora* gives rise to larger questions with broader conservation implications. If this species is present in Dallas County but unknown in the area between Dallas and its previously known range, the gap may result from a lack of studies on *Hexalectris* ecology and distribution. In this event, it would be possible for this species to be found in one or more of the intervening counties through targeted studies such as those conducted in Dallas County. However, it is also possible that the historic range of *H. grandiflora* included area between



Fig. 2. Photograph of *Hexalectris grandiflora* inflorescence at Cedar Ridge Preserve, Dallas County, Texas on 2 June 2006. Photo by Puttaswamy Ravishankar.

Dallas and West Texas, but this has since declined due to increased urbanization, and habitat loss and degradation. Determination of the ultimate causes and consequences of the recorded range disjunct may depend on continuing to answer fundamental ecological questions about this genus and factors influencing persistence of *Hexalectris* throughout its range.

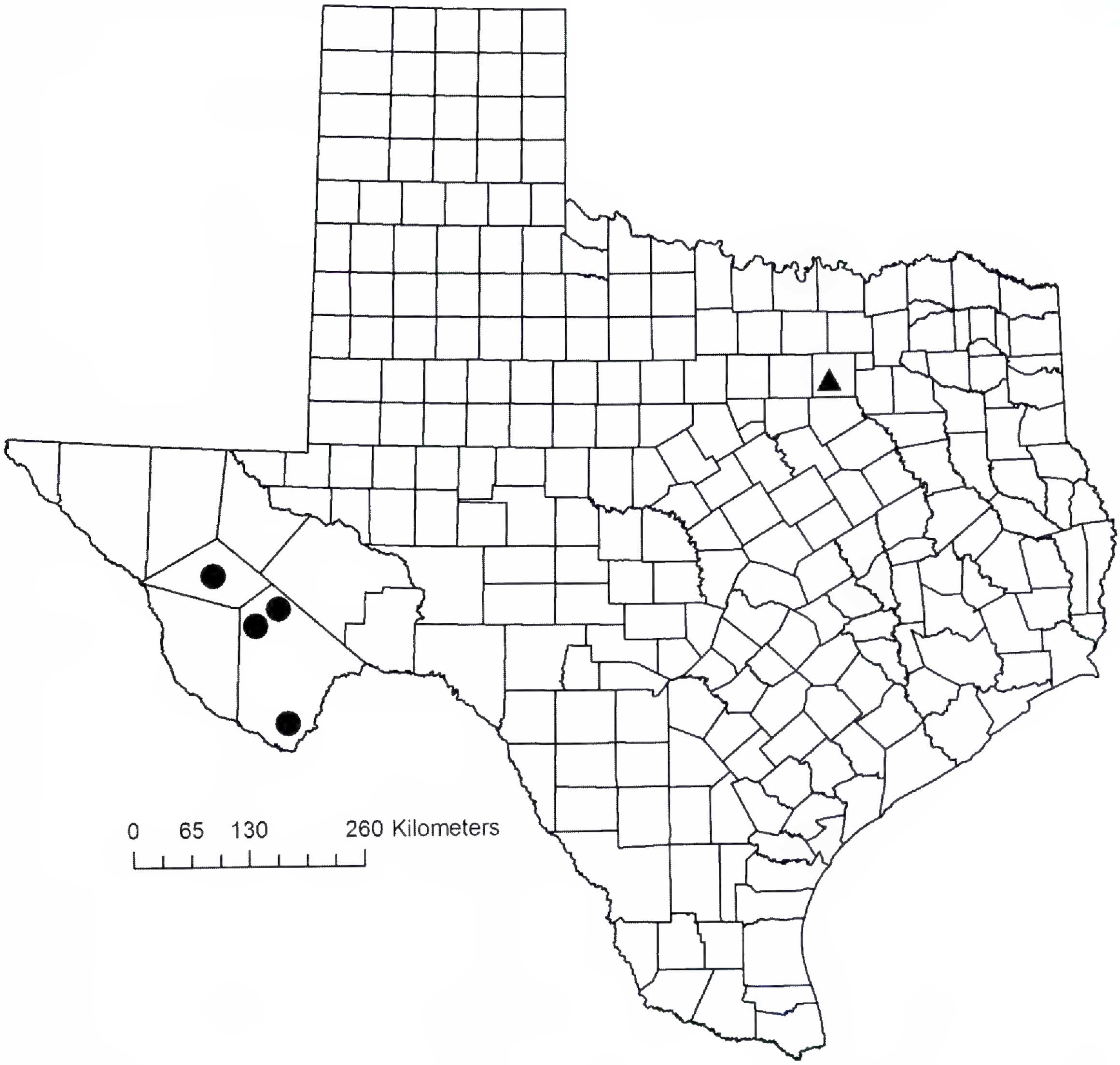


FIG. 3. Map of historic locations of *Hexalectris grandiflora* in Texas (circles; after Catling 2004) and the new locations found in Dallas County (triangle).

ACKNOWLEDGMENTS

We thank Circle 10 Council Boy Scouts of America administration and staff for allowing us access to the Camp Wisdom site. In particular, we acknowledge the assistance of Randy Schoen during our initial censusing effort, and Phil Augsberger, camp ranger at Camp Wisdom. Jim Varnum, Stephanie Varnum, Rigel Rilling, and Jenny Krabacher provided assistance in fieldwork. Aaron Kennedy (Miami University-Ohio) assisted in collecting tissue for laboratory analysis. Photography assistance was provided by P. Ravishankar.

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ERODIUM MALACOIDES (GERANIACEAE), NEW TO TEXAS

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ABSTRACT

Erodium malacoides (Geraniaceae) is reported as an addition to the flora of Texas. A description of the species and a key for identifying the Texas species of *Erodium* are provided.

RESUMEN

Se cita *Erodium malacoides* (Geraniaceae) como una nueva adición a la flora de Texas. Se aporta una descripción de la especie y una clave de las especies de *Erodium* de Texas.

Erodium L'Hér. comprises ca. 60 species of annual or biennial, rosette-forming herbs widespread in temperate and subtropical regions of the Old World and New World (Mabberley 1997). Three species have previously been recorded from Texas: the native *E. texanum* A. Gray, which is broadly distributed across central and southern portions of the state west to Utah and California, and the non-native species *E. cicutarium* (L.) L'Hér. and *E. botrys* (Cav.) Bert. (Jones et al. 1997). In Texas, *E. cicutarium* occurs in a variety of disturbed habitats in central, northern, and western regions of the state, while *E. botrys* has been collected from similar habitats in Bexar, Taylor, and Throckmorton counties (Correll & Johnston 1970; Turner et al. 2003).

In the spring of 2005, the senior author discovered a small population of *Erodium malacoides* (L.) Willd., a species previously unknown from the state, established on a disturbed site in Hays County, Texas. By 2006 the population had increased in size to hundreds of individual plants and occupied a substantially larger area, indicating a potential for naturalization. In the system proposed by Pysek et al. (2004), *E. malacoides* would be categorized as a "casual alien" in Texas.

Voucher specimens: **U.S.A. TEXAS. Hays Co.:** E side of northbound frontage road of Interstate Hwy. 35, City of San Marcos, N29° 53' 38", W97° 54' 31", 02 May 2006, *Aplaca 287* (SWT); W side of northbound frontage road of Interstate Hwy. 35, City of San Marcos, N29° 53' 39", W97° 54' 31", 02 May 2006, *Aplaca 288* (SWT); E side of northbound frontage road of Interstate Hwy. 35, City of San Marcos, N29° 53' 45", W97° 54' 25", 02 May 2006, *Aplaca 289* (SWT);

We can only speculate as to how *E. malacoides* may have been introduced at this location. Several years ago, activity associated with the construction of a new entrance ramp onto the interstate highway disturbed portions of the area now occupied by the species. The seed mix used for revegetation of the highway right-of-way, soil brought in as fill material, or vehicular traffic from Mexico represent the most plausible seed sources.

Erodium malacoides is native to southern Europe (Brandes 1995) but has become naturalized across the Mediterranean region (El Hadidi et al. 1984). It has been introduced as widely as Australia and New Zealand (Webb et al. 1988; Westbrooke & Florentine 2005), South America (Figueroa et al. 2004), and North America, where it has been reported from a number of Mexican states (Villaseñor & Espinosa-García 2004) and from



FIG. 1. **Upper photo**: Individual plant of *Erodium malacoides* from Hays Co., Texas, showing the characteristic simple, palmately lobed leaf and relatively small (ca. 10 mm diam.) flower. **Lower photo**: Close-up of flower showing the glandular pubescence of the calyx and the broad, entire-margined staminodes.

California (Taylor 1993), New York (Mitchell & Tucker 1997) and Massachusetts (Magee & Ahles 1999) in the U.S.A.

Plants of *E. malacoides* (Fig. 1) are annual herbs with decumbent to ascending, puberulent stems that are glandular at the nodes. The leaves are simple, 4–15 cm long including the petiole, which is generally longer than the blade. The leaf blades are ovate, crenate to shallowly palmately lobed, and puberulent. The small flowers are borne in umbellate clusters and have glandular-pubescent sepals 4–6 mm long, lavender to purple petals about as long as the sepals, five fertile stamens, and five broad, entire-margined staminodes. The fruit is a five-parted schizocarp that separates from the style column into single-seeded segments, each consisting of an indehiscent fusiform body with a more or less rounded, glandular apical pit subtended by a single furrow, and a persistent style segment that becomes tightly coiled when dry. The following key is provided to distinguish among the four species of *Erodium* presently known from Texas.

KEY TO THE SPECIES OF *ERODIUM* IN TEXAS

1. Leaf blades simple, often shallowly or deeply palmately lobed
   2. Stems appressed canescent; sepals 5–10 mm long, apically strigose; petals unequal, 7–12 mm long; staminodes long-awned, conspicuously ciliate; fruit body 5–8 mm long, the pit transversely elliptic and eglandular, furrows absent; style column 3–7 cm long _____ **E. texanum**
   2. Stems puberulent, the nodes glandular; sepals 4–6 mm long, glandular; petals equal, 4–6 mm long; staminodes awnless, entire-margined; fruit body 3–5 mm long, the pit ± round, glandular, and usually subtended by one furrow; style column 2–3 cm long _____ **E. malacoides**
1. Leaf blades deeply pinnately lobed to pinnately compound
   3. Stem pubescence glandular; sepals 3–5 mm long; fruit body 4–7 mm long, the pit subtended by a single furrow or furrow absent; style column 2–5 cm long _____ **E. cicutarium**
   3. Stem pubescence eglandular; sepals 10–13 mm long; fruit body 8–11 mm long, the pit usually subtended by two furrows; style column 5–12 cm long _____ **E. botrys**

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NEW DISTRIBUTION RECORDS FOR EUPATORIEAE (ASTERACEAE) IN THE UNITED STATES

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ABSTRACT

Several species of Eupatorieae occur in southern Arizona and New Mexico at the northern end of their otherwise Mexican distribution: *Stevia salicifolia* (reported from New Mexico by a single collection, the exact locality unknown and perhaps in immediately adjacent Mexico), *Ageratina* (*Eupatorium*) *thyrsiflora* (known from Arizona by a single collection), and *Koanophyllon* (*Eupatorium*) *palmeri* (previously confused with *K. solidaginifolium*). Reports of *K. palmeri* or *K. solidaginifolium* from New Mexico have not been confirmed. *Chromolaena* (*Eupatorium*) *bigelovii*, primarily a species of northeastern Mexico, is documented for the U.S.A. by three Texas collections—its occurrence was recorded in Arizona (cited from only the type collection), but that record apparently reflects a confusion of label data for the type, which almost certainly was collected along the Texas-Mexico border. Lectotypes are chosen for *Eupatorium arborescens*, *Koanophyllon* (*Eupatorium*) *palmeri* (var. *palmeri*), and *Ageratina* (*Kyrstenia*) *thyrsiflora*.

RESUMEN

Varias especies de Eupatorieae viven en el sur de Arizona y Nuevo México en el extremo norte de su distribución que de otro modo sería únicamente mexicana: *Stevia salicifolia* (citada de Nuevo México con una sola recolección, cuya exacta localidad es desconocida y quizás adyacente a México), *Ageratina* (*Eupatorium*) *thyrsiflora* (conocida de Arizona con una sola recolección), y *Koanophyllon* (*Eupatorium*) *palmeri* (previamente confundida con *K. solidaginifolium*). Las citas de *K. palmeri* o *K. solidaginifolium* de Nuevo México no han sido confirmadas. *Chromolaena* (*Eupatorium*) *bigelovii*, primariamente una especie del noreste de México, se documenta para los Estados Unidos mediante tres colecciones de Texas—su ocurrencia fue citada en Arizona (únicamente don la colección del tipo), pero esa cita refleja aparentemente una confusión de los datos de la etiqueta del tipo, que casi con seguridad fue colectado a lo largo de la frontera de Texas y México. Se eligen lectotipos de *Eupatorium arborescens*, *Koanophyllon* (*Eupatorium*) *palmeri* (var. *palmeri*), y *Ageratina* (*Kyrstenia*) *thyrsiflora*.

Preparation of Eupatorieae treatments for Mexico and the Flora of North America (FNA) region has brought to light three species previously unreported for the United States. Both are primarily distributed in western Mexico and are newly recognized as occurring in Arizona and New Mexico. A third primarily Mexican species is rare in Texas; it previously has been recorded as a member of the Arizona flora but, as discussed here, it does not occur in that state. Morphological descriptions of all four species are provided in the FNA treatments.

1. Stevia salicifolia

This species apparently has not been included for the U.S.A. in any published floristic account, but it was recorded in a dissertation study (Grashoff 1972) from southwestern New Mexico by a single collection of E.A. Mearns, naturalist for the United States and Mexican Boundary Survey of 1892–1894. Grashoff cited the collection as from Grant County, but the San Luis Mountains are a range primarily of northern Sonora and Chihuahua, Mexico, with an extension into Hidalgo County.

Voucher specimen: U.S.A. **New Mexico.** [**Hidalgo Co.**]: cañon east side of San Luis Mts., 11 Sep 1893, *Mearns 2220* (US).

In further refinement of the San Luis Mountains locality, Hubbard (1999) concluded that *Penstemon campanulatus*, which had been considered to be represented in the U.S.A. flora only by a Mearns collection, was collected on the Mexican side of the border rather than in New Mexico (cañon, east side San Luis Mts., 11 Sep 1893, *Mearns 2222* - US). In view of this, the U.S.A. record documented here for *Stevia salicifolia* should be considered doubtful, even though it seems likely that the species has stepped across the border in one place or another.

Geographic-ecological summary.—Flowering (Jul-)Aug-Oct (in northern Mexico). Oak and oak-pine woodland, rocky sites, crevices, boulder pockets; ca. 1500–2650 m (data from northern Mexico). New Mexico; Mexico (Michoacan, Edo. Mexico, Puebla, and Veracruz northward to Sonora, Chihuahua, Coahuila, Nuevo León, Durango, Zacatecas, San Luis Potosí). The range of var. *salicifolia* also closely approaches Texas and Arizona (see map in Turner 1997).

Stevia salicifolia is a variable species—many infraspecific taxa have been named but most were regarded by Grashoff as synonyms of var. *salicifolia*. Among the U.S.A. species of *Stevia*, *S. salicifolia* is distinct in its glabrous and shiny stem and leaf surfaces, which results from the viscid exudate of sunken glands; stems and leaves of the other U.S.A. species usually are sparsely pubescent and not shiny.

Stevia salicifolia Cav., Ic. 4: 32. pl. 354. 1797. "The TYPE ... came from plants cultivated at the Royal Botanical Garden, Madrid; Ortega states that the seed was sent from Mexico by Sesse." (McVaugh 1984, p. 895).

2. Ageratina thyrsiflora

This species is native primarily to the states of Sonora, Chihuahua, Sinaloa, Durango, and Jalisco in western Mexico (McVaugh 1984; Turner 1997). It is known from the United States only by a single collection near the international border.

U.S.A. **Arizona. [Santa Cruz Co.]**: near Nogales, 15 Sep 1929, *Harrison & Kearney 6039* (ARIZ fide Phil Jenkins, LL).

Geographic-ecological summary.—Flowering Sep–Nov. Rocky sites, oak woodland; 1000–2200 m (data from Mexican collections at TEX-LL and published notes of McVaugh 1984). Arizona; Mexico (Sonora, Chihuahua, Sinaloa, Durango, Jalisco).

Ageratina thyrsiflora is recognized by its strict, unbranched or few-branched stems with alternate, densely arranged leaves, small heads densely clustered in a single, terminal aggregate, prominently orange-veined corollas and phyllaries, and close cauline and petiolar puberulence of minute, sharply upwardly bent hairs. Morphology is relatively uniform over the geographic range, except in two collections from Sonora (*Muller 3655*, LL) and Chihuahua (*Gentry et al. 18026*, ARIZ, LL), where stipitate glands are mixed with the eglandular puberulence on lower stems and petioles. One collection from Jalisco (*McVaugh 21771*, LL) also shows a tendency to produce stipitate glands.

Ageratina thyrsiflora (E. Greene) R. King & H. Robinson, Phytologia 19:227. 1970. *Kyrstenia thyrsiflora* E. Greene, Leafl. Bot. Observ. Crit. 1:9. 1903. *Eupatorium thyrsiflorum* (E. Greene) B.L. Robinson, Proc. Amer. Acad. Arts 43:36. 1907. TYPE: MEXICO. CHIHUAHUA: Southwestern Chihuahua, Aug 1885, *E. Palmer 275* (LECTOTYPE selected here: US, internet image!). In the protologue, Greene cited the following: "Chihuahua, Mexico, chiefly southward in the State; collected by Palmer, Pringle, and E.A. Goldman, and always distributed for *E. occidentale* var. *Arizonicum* ...." A collection at GH was cited by McVaugh (1984) as "isotype" of *K. thyrsiflora* (near Chihuahua, 1 Oct 1885, *C.G. Pringle 613*), but there is no duplicate of this at NDG (fide Barbara Hellenthal) or at US. Greene perhaps studied the Palmer specimen at US before his time at the Smithsonian as an associate in botany (in 1904–1909); he did not annotate the Palmer sheet, however, even though he did make handwritten notations on US type sheets of *Kyrstenia calophylla*, *K. laeta*, *K. parvifolia*, and *K. rufa* (fide Barbara Hellenthal, pers. comm).

Eupatorium thyrsiflorum var. *holoclerum* B.L. Robinson, Proc. Amer. Acad. Arts 43:36. 1907.
TYPE: MEXICO. DURANGO: City of Durango and vicinity, Apr–Nov 1896, *E. Palmer 755* (HOLOTYPE: GH; ISOTYPES: MO!, US internet image!).

3. Koanophyllon palmeri

Koanophyllon (*Eupatorium*) *palmeri* is native primarily to western Mexico (McVaugh 1984; Turner 1997) and is known from the U.S.A. by collections from south-central Arizona. A similar taxon (*Eupatorium palmeri* var. *tonsum* B.L. Robinson) occurs in near-coastal localities from Michoacan to Colima, Jalisco, Nayarit, and Sinaloa. The Arizona plants are var. *palmeri* (which occurs southward through Sinaloa, Chihuahua, and Sonora to Durango and Jalisco). *Eupatorium arborescens* (as cited below) from Chihuahua is a synonym of *K. palmeri* var. *palmeri*.

Vouchers for records of *Koanophyllon palmeri* in southwestern New Mexico (Hidalgo and Grant counties—as mapped by Martin and Hutchins 1980) have not been located in New Mexico herbaria (J. Mygatt, UNM, pers. comm. and R. Spellenberg, NMC, pers. comm.). The basis for the Hidalgo County record may be a citation by Wooton and Standley (1915, p. 647) of a Charles Wright collection ("Guadalupe Pass, *Wright 1146*," [4–5 October, 1851]). According to Wooton and Standley (1915, p. 647), "Guadalupe Pass is on the southern boundary of the State, and Wright's specimens may have come from either Mexico or New Mexico." It seems reasonable to maintain *K. palmeri* as a member of the New Mexico flora, at least tentatively, especially in view of the map points shown by Martin and Hutchins (1980).

U.S.A. Arizona. Cochise Co.: Guadaloupe Mts., Guadaloupe Canyon, 13 Oct 1946, *Darrow et al. 3562* (LL). **Pima Co.:** W side of Mt. Baboquivari, 6 Oct 1944, *Gould et al. 2670* (LL); Baboquivari Mts., 25 Sep, 1927, *Harrison 4754* (LL); Baboquivari Mts., Sep 1931, *Hutchinson 6932* (LL); Sta. Catalina Mts., Sabino Canyon, 27 Sep 1934, *Kearney & Peebles 10257* (LL); Baboquivari Mts., 30 Sep 1934, *Kearney & Peebles 10373* (LL); Baboquivari Canyon, 11 Oct 1925, *Peebles et al. 413* (LL); Tucson Mts., Hugh Norris Trail, 7 Nov 1976, *Urry 840* (TEX); Waterman Mountains, NE end of road to Silver Hill Mine, 5 Dec 2001, *Van Devender 2001-1014* (TEX). **Santa Cruz Co.:** Coronado Natl. Forest, just to the E end of Forest Rd 217, near the Dos Amigos Mine, E of of Old Glory Canyon and Warsaw Canyon, 31 Aug 2001, *Goldman 2108* (BRIT); Peck Canyon, Atascosa Ranch, 18 Nov 1981, *Van Devender s.n.* (TEX); Holden Canyon, 1 mi NW of Bartlett Mts., 29 Oct 1981, *Van Devender & Toolin s.n.* (TEX).

Geographic-ecological summary.—Flowering Sep–Nov(–Dec). Shaded rocks along streams, crevices, often in oak woodland; 850–1500 m. (data from Arizona collections).

Koanophyllon palmeri (A. Gray) R. King & H. Robinson, Phytologia 22:150. 1971. *Eupatorium palmeri* A. Gray, Proc. Amer. Acad. Arts 21: 383. 1886. Gray did not cite a specific collection but noted "type locality, 'shady places high up in mountains above Batopilas.'" TYPE: MEXICO. [CHIHUAHUA]: Southwestern Chihuahua, August to November 1885, *Palmer 144* (LECTOTYPE designated here: GH!; ISOLECTOTYPE: US internet image!). Another collection, *E. Palmer 263* (GH!), is similarly labeled. Both GH sheets were annotated by Gray as "Eupatorium palmeri n. sp." McVaugh's account (1956) of Palmer's itinerary indicates that collections in the vicinity of Batopilas were made in August through early October 1885.

Eupatorium arborescens M.E. Jones, Contr. West. Bot. 12:43. 1908. TYPE: MEXICO. CHIHUAHUA: Sierra Madre Mts., Guayanopa Canon, 3600 feet alt., in the Tropical Life Zone, 24 Sep 1903, *M.E. Jones s.n.* (LECTOTYPE designated here: RSA-POM 41799, photocopy!; ISOLECTOTYPE: RSA-POM 41800, photocopy!). The two sheets exactly match the protologue in label data and probably are duplicates of the same collection; 41799 bears a single branch; 41800 has two branches. Each sheet is labeled in the same handwriting (apparently that of Phillip Munz, fide Michael Denslow at RSA-POM) "Part of type, *Eupatorium arborescens* Jones." Leaf position, vestiture and involucral features are those of *K. palmeri*, although the acuminate leaf apices are more similar to those of *K. solidaginifolium*.

Plants of *Koanophyllon palmeri* in Arizona have been previously identified as *K. solidaginifolium* (A. Gray) King & H. Robinson (= *Eupatorium solidaginifolium* A. Gray,

see citation below). As interpreted here, however, and in Turner (1997) and Blake (1924), *K. solidaginifolium* occurs in north-central Mexico (eastern Chihuahua, Coahuila, northeastern Durango, northern Zacatecas) and into the trans-Pecos area of Texas, east of the range of *K. palmeri*. Their ranges approach each other in central Chihuahua, but the two apparently are allopatric. The following contrast separates the two species in the U.S.A. and northwestern Mexico.

Leaves all opposite, blades apically acute, upper surfaces sparsely strigose to weakly hispidulous; involucres (3–)3.5–4 mm long; phyllaries herbaceous to the margins, at least the outer puberulent, all usually weakly ciliate, outermost ovate-elliptic to obovate _____ **Koanophyllon palmeri**

Leaves usually subopposite to alternate on distal third of stem, blades apically long acuminate, upper surfaces glabrous; involucres 4.5–5.5 mm long; phyllaries with narrow but distinct hyaline-translucent margins, glabrous and eciliate, outermost narrowly lanceolate. _____ **Koanophyllon solidaginifolium**

Eupatorium solidaginifolium A. Gray, Smithsonian Contr. Knowl. 3(5) [Plant. Wright. 1]: 87. 1852. TYPE: "Collected in Expedition from Western Texas to El Paso, New Mexico, May–October, 1849, by Charles Wright" [as on label], *Wright 256* (HOLOTYPE: GH, photocopy!; ISOTYPE: GH, photocopy!). Gray's citation in the protologue was "Mountains between the Limpia and the Rio Grande, New Mexico." According to I.M. Johnston's commentary on Wright's field notes (fide Walter Kittredge, GH), this locality matches Wright's field number of '256,' as recorded on the type labels. Limpia Creek and Limpia Canyon are in present-day Jeff Davis Co., Texas, and it is probable that Wright's collection was made there (recent collections document the species in Jeff Davis Co. and Presidio Co.), probably in late August (as inferred from Wooton 1906). The specimens were annotated as 'holotype' and 'isotype' by D.E. Boufford in 1981.

4. Chromolaena bigelovii

Chromolaena bigelovii has been included in various summaries of the Arizona flora (e.g., Kearney & Peebles 1951; Lehr 1978) on the basis of the protologue, which cited "On the Gila, Sonora; *Parry*." Kearney and Peebles (1951, p. 845) observed that the species is "apparently known in Arizona only from the type collection on the Gila River (*Bigelow*)," and the present authors have located no further records of the species from Arizona. In contrast, plants matching the type of *C. bigelovii* (below) have been collected at numerous localities in northeastern Mexico (Coahuila, Nuevo León, San Luis Potosí—Turner 1997) and at two sites in Texas (mapped in Turner et al. 2003; documented here). *Eupatorium madrense* (as cited below) from Nuevo León is a synonym of *Eupatorium bigelovii*.

U.S.A. Texas. Brewster Co.: Big Bend National Park, Basin of Chisos Mt., base of Baldy Peak, 6 Sep 1950, *Warnock 9587* (SRSC); Big Bend National Park, Sierra Quemada, Claro 2 Spring, 29 Oct 2000, *Bartel 211* (SRSC). **Uvalde Co.:** on chalk bluffs at Park Chalk Bluff along the Nueces River, ca. 15 mi NW of Uvalde, 12 Dec 1967, *Correll 35433* (LL).

Geographic-ecological summary.—Flowering Oct–Dec. Dry limestone hills in oak woodlands, talus; ca. 1000–1800 m. (data primarily from Texas, Coahuila, and Nuevo León).

Chromolaena bigelovii (A. Gray) R. King & H. Robinson, Phytologia 20:208. 1970. *Eupatorium bigelovii* A. Gray in Torrey, Rep. U.S. & Mex. Bound. Survey, Bot. 75. 1859. TYPE: U.S.A. [locality uncertain but probably along the Texas-Coahuila boundary, 1848–1855], *J.M. Bigelow 12* (probable HOLOTYPE: GH, photocopy!). The protologue by Gray cited "On the Gila, Sonora; *Parry*." Blake (1924) and Kearney and Peebles (1951) noted that the locality should be placed in Arizona than Mexico. Specimen labels, however, on a collection that is reasonably interpreted as the type are annotated in Gray's handwriting as "E. bigelovii n. sp." and "E. bigelovii Gray" and do not have locality information. On the original label, "Mex. Bound. Survey No. 12," a note by Gray says "Bigelow—locality not recorded"; another note (B.L. Robinson's handwriting) reads that "Identical material in Paris Herb. and Berlin Herb. bears Mex. Bound. Surv. label numbered (in pencil) 471." A Parry collection that would represent a potential type for *Eupatorium bigelovii* has not been located at GH.

The species represented by the Bigelow collection is the one that has been collected numerous times in northeastern Mexico and immediately adjacent Texas. The collection almost certainly was made along the Texas-Mexico boundary, in the known range of the species, in the region covered by the United States and Mexican Boundary Survey of 1848–1855, for which Bigelow worked as a naturalist. Numerous collections by Bigelow from southwestern Texas are specifically cited in the Survey's "Botany" report. In the tentative interpretation here, a mistake in manuscript preparation apparently led to a substitution both for the correct collector (Parry instead of Bigelow) and correct locality (On the Gila, Sonora, instead of 'along the Texas border'). Gray's choice of epithet supports this interpretation.

Eupatorium madrense S. Watson, Proc. Amer. Acad. Arts 26:137. 1891. TYPE: MEXICO. Nuevo León: Sierra Madre near Monterey, 7 Jun 1888, *C.G. Pringle 2201* (HOLOTYPE: GH photocopy!).

ACKNOWLEDGMENTS

We are grateful to Steve Boyd and Michael Denslow (RSA-POM) for information and photocopies of *Eupatorium arborescens*, Phil Jenkins and Michael Chamberland (ARIZ) for checking potential occurrences of *Chromolaena bigelovii* at ARIZ, Phil Jenkins for comments on *Ageratina thyrsiflora*, Jane Mygatt (UNM) and Rich Spellenberg (NMC) for providing information on New Mexico collections, Barbara Hellenthal for checking the potential occurrence of collections at NDG, Harold Robinson (US) for review comments, and Emily Wood and Walter Kittredge (GH) for providing information and photocopies of various GH collections.

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Book Reviews

Bruce A. Bohm. 2004. **Hawai'i's Native Plants**. (ISBN 1-56647-666-6, pbk.). Mutual Publishing, 1215 Center Street, Suite 210, Honolulu, HI 96816, U.S.A. (**Orders:** 808-732-1709, 808-734-4094 fax, mutual@mutualpublishing.com, www.mutualpublishing.com). $22.95, 224 pp., approx. 200 color photographs, 6" × 9".

Dr. Bruce A. Bohm's *Hawai'i's Native Plants* presents a historical view of botany on the Hawaiian islands and is quite pleasant to read. I must begin by saying that *Hawaii's Native Plants* is *not* a field guide for quick identification of plants. Rather, it carefully introduces the geologic, ecological, evolutionary and cultural history of each major taxonomic group, often in too much detail for the lay reader. This book is not organized like a traditional field guide; species information is presented in narrative form with headers of both Genus and Hawaiian names introducing each group. Excellent color photographs throughout the book provide identifying characteristics of species, though not all species are photographed. That being said, this book would be an excellent reference/companion for a "quick-identification" field guide of Hawaiian plants.

This work begins with a chapter (*The Islands*) on the geologic, ecological and cultural history of the Hawaiian Islands. It gives a brief introduction to each island, giving descriptions of vegetation patterns as well as brief historical backgrounds. This first chapter reads almost like a travel guide to Hawai'i, but is a good introduction to the processes and historical events that have helped shape the islands' current flora and fauna. Bohm focuses on plants that are easily accessible to the amateur naturalist/tourist but does include some more challenging-to-find species. His stated audience is persons traveling to Hawai'i; his goal is for the reader to become appreciative of Hawai'i's native flora and informed of the current threats to Hawai'i's biodiversity. However, the average tourist (especially if he/she has no background in biology or geology) may find this book a challenging read because of the detail in which Bohm discusses biological and geological processes.

Native Hawaiian Plants, the second chapter, is the one that provides the taxon-specific descriptions and introduction to the major groups of native Hawaiian plants; thus, it makes up the majority of the book. As mentioned above, the plants are introduced using headings of the Genus and Hawaiian name(s). Plants are first described for identification purposes, and then the evolutionary history and ecological characteristics of most groups are discussed. For most of the taxa, these short literature explorations may lead the lay reader to loose interest in the technical information presented (i.e. phylogenetic analysis or molecular genetics techniques). Conservation status, native cultural uses, factors that have affected the colonization, distribution, and population dynamics of species (e.g. major storms, volcanic activity, human activity) are a great addition to this book, as this information is rarely included to this extent in traditional field guides. The end of this chapter contains a small section entitled *Ferns and Fern Allies*; it is short and limited to relatively easy to find species. The author suggests Daniel Palmer's *Hawai'i's Ferns and Fern Allies* (2003) for a more comprehensive guide to this group.

The third chapter, *Alien Invasion*, discusses the extent to which invasive plants have affected native flora and fauna. The author includes this chapter in hopes that the reader will gain an appreciation for the "full impact" invasive species can have on native biota. He introduces invasive plants by taxonomic group and discusses how each group became introduced to the islands, focusing on species considered to be *invasive* as opposed to *naturalized* or *introduced* species. There is also discussion of the ecological characteristics of invaders that have made them so successful on Hawai'i and of current efforts that are being made to eradicate (or try to eradicate) invasives.

The final chapter (*There Is No Future In Extinction*) begins with a discussion of extinction in general, contemporary species loss and biological characteristics that may make certain taxa more prone to extinction. In this chapter Bohm gives the reader an abundance of literary references on extinction for further exploration. He includes a brief presentation of global hotspots of plant diversity and endemism, then discusses threats specific to Hawaiian flora and describes specific conservation efforts to preserve or restore native populations of Hawaiian plants. Finally, the author provides a short appendix at the end of the book that explains methods commonly used by taxonomists to identify and study evolutionary history of species, including molecular phylogenetics techniques that have allowed for better identification of plants.

For avid natural historians with some background knowledge of geology, evolution and ecology, this book is a welcome addition to the botanical literature on Hawai'i. Professors teaching courses on Hawaiian natural history or botany would find this a useful volume; it is also quite affordable for students. *Hawaii's Native Plants* would best be read in its entirety before a trip to Hawai'i to develop an understanding of the basic relationships between plant taxa and ecology of plant groups. This book also provides information on easily accessible sites to find certain species (often roadside access), and would be a useful tool for planning outings on trips.—*J. Hayley Gillespie, University of Texas at Austin, Integrative Biology, Austin, TX 78712, U.S.A., hayleygillespie@mail.utexas.edu*

MELINDA A. ZEDER, DANIAL G. BRADLEY, EVE EMSHWILLER, and BRUCE D. SMITH (eds.) 2006. **Documenting Domestication: New Genetic and Archaeological Paradigms.** (ISBN 978-0-520-24638-6, hbk.). University of California Press. Berkeley, Los Angeles, London. (**Orders:** California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, New Jersey 08618; Tel.: 609-883-1759; Fax: 609.883-7413) $70.00, 361 pp., b/w figures, b/w photos, tables.

Although interdisciplinary studies were well underway during the last century, *Documenting Domestication: New Genetic and Archaeological Paradigms* definitely sets a new standard for scientific investigations, integrations, and interpretations for the 21st Century. Certainly, rapidly advancing electronic technologies for entering, storing, and retrieving data rapidly and accurately have provided the necessary tools to enable and facilitate research and interpretation and to utilize materials from a much larger body of assemblages and studies. Moreover, such sophisticated developments as high-power scanning electron microscopy and techniques "for the recovery and identification of plant macro- and micro-fossils" have greatly expanded and enhanced archaeobiological and genetic studies.

A symposium presented at the annual meetings of the American Association for the Advancement of Science (2001) featured four speakers, each addressing progress and future concerns and challenges in his/her specific studies "on the domestication of plants and animals from archaeological and genetic perspectives." That provided the impetus for this volume, and three of those speakers are editors as well as contributors.

The overarching introductory chapter, "Documenting Domestication: Bringing Together Plants, Animals, Archaeology, and Genetics," is written by the editors. It provides an in-depth overview of earlier work from the mid 19th Century, beginning with perceptions from Darwin and continuing through the present, with its rapidly expanding resources and technologies. Discussions of changing approaches and understandings of the scientific disciplines herald fresh new ways of gathering and interpreting data, not only from newly collected evidence but from renewed examination of existing data.

The book is designed on a "four-celled matrix" (table 1.1). Research for domestication of plants and animals is documented in special sections based on archaeological studies and on genetic studies. Each editor is responsible for one of those sections: Bruce Smith, the archaeology of plant domestication; Eve Emschwiller, the genetic documentation of plant domestication; Melinda Zeder, archaeology of animal domestication; and Dan Bradley, the genetics of plant domestication.

Each editor has written an overview chapter preceding the articles in that category. This is very helpful for the reader, and it permits rapid identification of chapters likely to be relevant to one's own interest or research.

The chapters within each section comprise an intriguing glance into specific studies and provide information that previously has not been easily available. The reader's interest will undoubtedly be drawn first by those that most pique his/her interest (dogs and olives for me, but I enjoyed the entire volume).

The abundance of figures (including photos and drawings) and the many tables (giving easy visual perception of data and relationships) are welcome additions.

Another plus for this volume is the wide diversity of geographic areas covered by the researchers. The range of documented areas includes North and South America, Eurasia, and the Middle East. That breadth of research enhances the diversity of key animal and plant coverage and is extremely helpful in analyzing the data. (To date, most studies have been centered on specific, often very small areas; comparison with assemblages from other sites can be very distorted. It is not easy to trace or compare interactions or formulate valid interpretations unless the retrieved data were based on the same or similar procedures and markers.)

Interestingly, the new methods, tools, data retrieval, ease of comparison across geographic areas, and access to new information being immediately available from remote study areas have permitted workers to re-think older, accepted interpretations and to construct solid new paradigms.

New questions, better understanding and new interpretations of evidence from ancient archaeological assemblages, abilities to identify phytoliths in plants or study canine mtDNA data, access to previously inaccessible studies...all of these things enable researchers to study the evidence again and refine or change the interpretations.

Planning and execution of this volume are both thorough and professional. The use of Vincent van Gogh's "The Sower" for the cover is particularly pleasing and appropriate.

Scientists and historians usually concur that the domestication of plants and animals is one of the major determining events in the history of mankind. This volume is a welcome contribution to the current understanding.—*Helen Jeude, Botanical Research Institute of Texas, Fort Worth, Texas 76102-4060, U.S.A.*

GEORGE YATSKIEVYCH. 2006. **Steyermark's Flora of Missouri Volume II- Revised edition.** (ISBN 1-930723-49-0, hbk.). Missouri Botanical Garden Press, P.O. Box 299, Saint Louis, MO 63166-0299, U.S.A. (**Orders:** http://www.mbgpress.info/). $48.00, 1181 pp., b/w line drawings, maps, 7 3/8" × 9 7/8".

To anyone interested in the Missouri Flora Project, George Yatskievych's revision of the original *Flora of Missouri* by Julian Steyermark was looked forward to with great anticipation. Volume 1, published in 1991, covered pteridophytes, gymnosperms, and monocots. It was so well written, organized, illustrated and thorough, that Missouri botanists anxiously awaited Volume 2. Published in June 2006, Volume 2 covers the first part of the dicots alphabetically from the Acanthaceae through two subfamilies of the legumes or Fabaceae (Caesalpinoideae and Mimosoideae). Volume 2 is so well done that the author has even surpassed the excellence of Volume 1 and students of Missouri's flora have been greatly rewarded for their patience. Each species account includes a detailed description that is the most thorough I have ever observed in any North American floristic manual. Also provided are blooming periods, county dot range maps, characteristic habitats, relative abundance and illustrations for the overwhelming majority of species. Most taxonomic treatments follow the findings outlined in most recently published literature, especially, for the most part, the rearrangement of genera within the Asteraceae that has been adopted in various up to date manuals (e.g., Flora of North America).

Even without the artwork, Volume 2 is a monumental achievement. Nonetheless, the illustrations are so detailed and so complete that the 193 plates are the most accurate representation of treated species I have seen in any flora. One aspect I particularly like is the enlarged detail of the fruit illustrated that is easy to recognize, especially for genera and species that are often difficult to visualize in sufficient detail to distinguish between closely related taxa (e.g., species of *Vernonia*, plates 299 and 300; and species of *Cuscuta*, plates 364 and 365). Another highlight is that the Brassicaceae includes keys for both flowers and fruit (pp. 651-659). Anyone who has ever tried to key out material in this family will find the separate approaches extremely helpful. Overall, the keys function well and the glossary on pages 1085-1102 covers terms that may be unfamiliar to some readers.

Volume 2 is such a quality compilation of information that it is hard to find fault. Nonetheless, there are a few minor points that should be brought to light. The most obvious oversight is that the numerous genera and species within the Asteraceae are arranged by Tribe. Although this alignment is helpful in simplifying keying exercises (pages 167-171), it is extremely frustrating for readers who do not know what tribes various genera are ascribed, especially given the recent taxonomic changes within the family. To locate a specific genus within the Asteraceae, the reader must locate it by thumbing through 42 pages of index (pages 1139-1181). A potential solution would have been to list all genera within each tribe near the beginning of the discussion on the Asteraceae. Another shortcoming of the book is that the treatment does not cover the last subfamily of the Fabaceae (i.e., Faboideae) which includes most of the species of legumes documented for the state. Obviously, any writer of a book this size must establish a cut off somewhere, but it would have been advantageous for the entire family to be covered together. Although undoubtedly a selfish and unrealistic expectation of this reviewer, it would be have been helpful to include a key that included all dicot families, especially given the length of time that is likely required to complete the last treatment. With any book of such magnitude, minor errors are sure to be inherent but only a few have been identified to date. The couplets separating *Helenium autumnale* from *H. virginicum* in the key on page 490 were inadvertently transposed. *Helenium virginicum* should be 3a, not 3b. On plate 386 (page 1067), the fruiting branch illustrated for *Senna obtusifolia* should be labeled 10e and the fruiting branch for *S. occidentalis* should be labeled as 10f.

In conclusion, *Steyermark's Flora of Missouri- Volume 2* is nothing less than a botanical masterpiece in print and it clearly warrants a spot on the shelf of every botanist in Missouri. Because its application and coverage includes many species that have been documented for many states in the Midwest and eastern Great Plains, it would make an excellent reference book for anyone studying plants in the eastern United States.—*Paul M. McKenzie, U.S. Fish and Wildlife Service, 101 Park DeVille Dr.; Suite A, Columbia, Missouri 65203, U.S.A., Email: paul_mckenzie@fws.gov*

Report and update 2006

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To all authors, we thank you for choosing *Sida, Contributions to Botany* as your forum to disseminate information and knowledge gained by scientific inquiry. Volume 22, complete in two numbers, will be the last volume of the journal title. Volume 22 has 1274 pages, 169 authors, 105 published contributions, and includes 97 new names and new combinations. Published papers are available online in Adobe Acrobat format (PDF files); the PDF files are true representations of the hard copy of Sida <*http://www.brit.org/sida/SCBCurIssue.htm*>.

A word of thanks to the 298 individuals acknowledged on pages 1258–1259, who generously supported Sida through their time and expertise in reviewing 226 manuscripts submitted for volume 22. All manuscript submissions are peer-reviewed by distinguished reviewers; your support is deeply appreciated. If by chance you reviewed a manuscript and your name was left out, the error rests solely on the shoulders of this editor and I truly apologize. Please bring any omissions to my attention.

Below are the dates of publication for the two issues of volume 22, subscriptions. We also bring to your attention (see bottom of this page) the *Mary M. Hennen Scientific Publications Endowment*, established to provide support to the future of BRIT's scientific publication program (*Sida, Contributions to Botany* and *Sida, Botanical Miscellany*). The index to volume 22 (2006) follows. Guidelines to contributors are available online at *http://www.brit.org/sida/SubmitPaper.htm*.

We thank all authors, reviewers, subscribers (individuals, institutions, organizations), and readers for your continued interest and support. It is our plan to continue bringing you the best sources of current research in classical and modern systematics with your continued support. Wishing you the best in 2006 and beyond.—**Barney Lipscomb** (BRIT), Editor; **John W. Thieret**† (NKU), Associate Editor; and **Félix Llamas** (LEB), Contributing Spanish Editor.

Dates of publication

22(1), pp. 1–846: 11 August 2006

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Mary M. Hennen Scientific Publications Endowment Established.—In honor of his wife, **Mary**, BRIT research associate, professor emeritus of botany at Purdue University, the world's pre-eminent authority on the systematics and biogeography of the rust fungi, **Joe Hennen** has established the *Mary M. Hennen Scientific Publications Endowment* to provide support to the future of BRIT's scientific publication program. Joe and Mary (life-science librarian at Purdue University) have long recognized that publication of scientific botanical information is an integral part of conserving our natural heritage.

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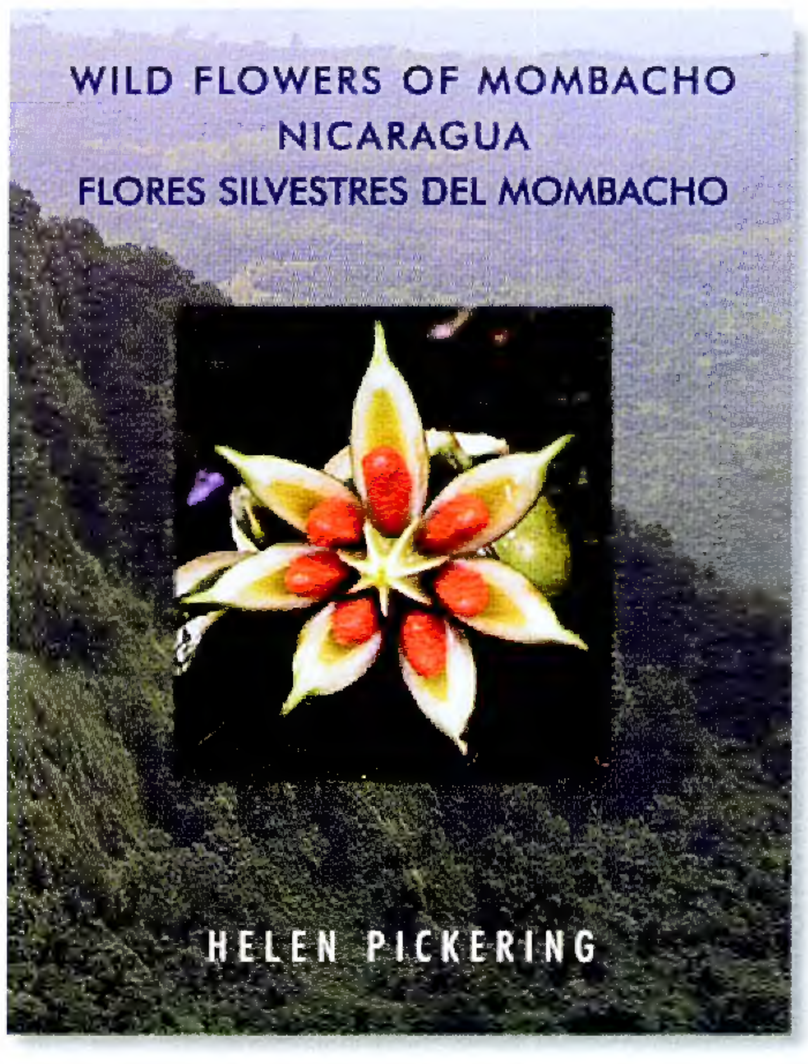
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